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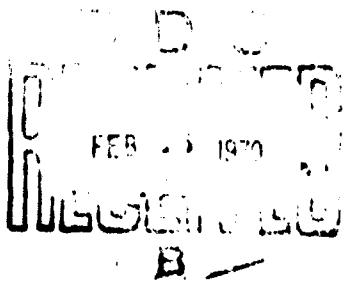
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TITLE: STORAGE, RETRIEVAL AND PRESENTATION OF

MICROFORMATTED TECHNICAL MANUAL

INFORMATION,

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LOGISTICS TECHNOLOGY DEVELOPMENT (Org. 2-5042)

SHEET 1

US 4002 1430 REV. 9/60

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ABSTRACT

The acceleration in the bulk of printed information required to maintain today's complex systems is described. A solution to this maintenance problem is presented, namely, microfilming and storing the information in equipment from which it can be randomly retrieved and displayed. Equipment suitable for the storage and dissemination of technical manual information at the point of use is investigated. Airline technical manual microfilm applications are reviewed. The results of recent military maintenance information storage and presentation studies and applications are also reviewed and critiqued. The following conclusions are reached: - -

o   Acceptable reader-printers are available.

o   Employment of the new display equipment and microformatted information systems will alleviate many of the current technical manual storage, file integrity, retrieval time, updating and distribution problems.

o   However, the solution to the maintenance dilemma will not be solved by simply microfilming the conventional technical manuals and employing the new display equipment. An overhaul of existing technical manual specifications (requirements determination, development concept, content, format and indexing requirements) is recommended so that maximum use may be made of the new retrieval and display equipment potential.

KEY WORDS

Audio-Visual Maintenance Information Systems
Information Storage, Retrieval and Presentation Systems
Maintenance Information
Microfiche
Microfilm
Microforms
Operation Information
Photomicrography
Programmed Manuals
Technical Information Display Systems
Technical Orders
Technical Manuals

USE FOR TYPEWRI ..N MATERIAL ONLY

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USE FOR TYPEWRITTEN MATERIAL ONLY

GLOSSARY

Access, Random
: The process of obtaining information from or placing information into a memory or storage system when there is no systematic relation governing the successive locations or positions involved.

Aircraft Unscheduled Maintenance
: Those unpredictable maintenance requirements (not previously planned or programmed), which require prompt attention and must be added to, integrated with, or substituted for previously scheduled workloads. This includes compliance with technical work orders, correction of discrepancies discovered during flight or operation of equipment, replacement of unscheduled accessory failures, and performing repairs required as a result of accidents or incidents.

Aperture Card
: A punched card with an opening specifically prepared for the mounting of a frame or frames of microfilm. Also, tab cards that usually have one frame of 35mm film mounted within an aperture cut into the card. The reduction ratio is usually 16:1, and its primary application is in the area of engineering drawings. Each aperture card usually contains one engineering drawing.

Automated Technical Data
: Refers to mechanical or electro-mechanical devices which perform predetermined sequence of operations to retrieve desired technical information from storage without further human operator assistance after initial stimuli application. The automation process, through utilizing various degrees of automatic control, improves human productivity in the processing of information and materials.

Camera, Planetary (Flat-Bed)
: A type of microfilm camera in which the document being photographed and the film remain in a stationary position during the exposure.

GLOSSARY (Continued)

Camera, Rotary (Flow)	A type of microfilm camera that photographs documents while they are being moved by some form of transport mechanism. The document transport mechanism is connected to a film transport mechanism, and the film also moves during exposure so there is no relative movement between the film and the image on the document.
Camera, Step-and-Repeat	A type of microfilm camera that provides a series of latent image frames in a predetermined pattern on a single sheet of film.
Character	One representation of a numeric digit, letter of the alphabet, or any other symbols that a computer may read, store, or write.
Contact Printing	Reproductions made by exposure of sensitized material in direct contact with that which is being copied.
Diazo	An organic, light-sensitive dye coated on a material and processed by ammonia fumes or an alkaline solution.
Direct Image Film	A term used to describe the type of film that produces a negative from a negative and a positive from a positive in one step.
Direct Positive	A positive image obtained directly from another positive image without the use of a negative intermediate. This process will also produce a negative directly.
Dummy	A detailed layout showing the size and position of all elements on the pages of a book or a section of a book. Proofs of type and illustrations may be pasted into the layouts (paste-up dummy). A sample book, usually of blank pages, made up to show the size, binding, quality of paper, etc., for a projected book.

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GLOSSARY (Continued)

Enlargement Ratio	The ratio of the linear measurement of a micro-image of a document to the linear measurement of the enlarged image, expressed as 15x, 20x, etc.
Experienced Mechanic/ Technician	A mechanic properly trained in a service school with appropriate on-the-job training. The mechanic can perform maintenance tasks without direct supervision. A five level (E-5) mechanic or above.
Film Master	That film from the first microfilming of a document. Also known as the original film.
Film Frame	The area of film exposed to light through the camera optical system for one image, regardless of whether or not the area is filled by the document image.
Format	The whole physical form of a book, including its dimensions, page design, type style, etc.
Hard Copy	(1) A human-readable copy produced from information that has been transcribed to a form not easily readable by human beings. (2) A document or reproduction that can be read without optical aids.
Human Engineering	The art or science of designing, building, equipping, testing an equipment, system or subsystem to the anthropometric, physiological, or psychological requirements of a person.
Integrated Data Concept	A theory of parallel, coordinated technical data development. This theory proposes that final technical manual requirements be considered during initial equipment design and procedural support data development. This consideration would include production of multi-purpose technical data in parallel with development of weapon system equipment.

GLOSSARY (Continued)

Job Performance Aid

Performance aids are items of auxiliary equipment or documents used by a maintenance man to guide himself while he is performing a task of his job. They are designed to help (the technician) by providing step-by-step instructions for the job at hand. They store information, present it to the task performer, process it, or accept information from the task performer. Performance aids may be in the form of manuals, checklists, slide rules, film strips or recorded auditory instructions.

Kalvar

A trademark for the film and equipment products of Kalvar Corporation.

Magnification

The linear ratio of the size of the image to that of the object.

Microfiche

A French word meaning a "small accumulation of data." Microfiche are flat sheets of microfilm on which many pages of data are reduced dependent upon size of sheet or reduction ratio. Two standard reduction ratios are widely used. . 20:1 and 24:1. At 20:1, the COSATI (Committee on Scientific and Technical Information) fiche contains up to 60 pages, and a 24:1, the National Microfilm Association (NMA) commercial fiche contains up to 98 pages.

Microfiche Jacket

The microfiche jacket is a means of housing strips of microfilm by trapping them between two panels of Mylar film. Each strip of film rests in what is known as a chamber. The jacket, with the film strips in it, can be used directly to create duplicate fiche copies.

Microfilm

(1) The recording of microphotographs on film. (2) A processed photographic film containing microphotographs.

Microform

A generic term for describing any miniaturized form containing micro-images. Microcards, microfiche, and microfilm aperture cards are all microforms.

GLOSSARY (Continued)

Microimage

A unit of information such as a page of text or a drawing too small to be read by the unaided eye.

Printer, High-Speed

High-speed printing that makes use of rotating print wheels or a chain with raised type faces and fast-acting hammers to press the paper against the desired character at the instant it is in the correct position.

Printer, Projection

A photographic printer in which the negative is projected onto the print material. The image of a print made with a projection printer may be smaller, larger, or equal size.

Resolution

The ability to render visible the fine details of an object; a measure of sharpness of an image, expressed as the number of lines per millimeter discernible in an image. Resolution in processed microfilm is a function of film emulsion, exposure, camera lens, camera adjustment, camera vibration, and film processing. Resolution is measured by examining a microfilmed resolution test chart under a microscope to determine the smallest pattern in which lines can be distinguished both horizontally and vertically.

Revision

Technical manual changes to reflect equipment changes during a designated period of time. A revision consists only of added or revised pages, as opposed to a reissue.

Roll Microfilm

A length of microfilm on a reel, spool, or core.

Scanning Device

A mechanism that permits shifting the film or the entire optical system so that different portions of the microfilm frame or reel may be viewed.

Second Reproduction Microfilm

Microfilm made from the "First Reproduction Microfilm" also called third-generation microfilm.

GLOSSARY (Continued)

Systems Analysis

An orderly study of the detailed procedure for collecting, organizing, and evaluating information about an organization with the objective of improving control over its operations.

Technical Data

Technical data are recorded information used to define a design and to produce, support, maintain or operate items of defense materiel. These data may be recorded as graphic or pictorial delineations in media such as drawings or photographs; text in specifications or related performance or design type documents; in machine forms such as punched cards, magnetic tape, computer memory printouts; or may be retained in computer memory. Examples of recorded information include engineering drawings and associated lists, specifications, standards, process sheets, manuals, technical reports, catalog item identifications, and related information.

Technical Data System
for Unscheduled Maintenance

A composite of data presented for visual interpretation by means of a device, with printer and/or audio capability, which portrays the necessary technical data to perform unscheduled maintenance. The system may be linked to the materiel being tested or located separately. (The individual test stations can be centrally controlled and updated).

Technical Manuals

Publications and other forms of documentation containing a description of equipment, weapons, or weapon systems, with instructions for effective use, including one or more of the following sections as required: instructions covering initial preparation for use; operational instructions; maintenance instructions; overhaul instructions; parts list or parts breakdown; and related technical information or procedures.. Department of Defense Instruction 4151.9, Technical Manual Management, January 24, 1969

LISTING OF ACRONYMS RELATING TO IMPROVED
MAINTENANCE INFORMATION PRESENTATION
SYSTEMS

ACE	Automatic Circuit Evaluation (Philco)
ADMIRE	Automated Diagnostic Maintenance Information REtrieval (Westinghouse)
ATOMS	Automated Technical Order Maintenance Sequences (Boeing)
A-VIS	Audio-Visual Information System (Nike - X)
DATOM	Data Aids for Training Operations & Maintenance (Navy/General Electric)
DD	Design Disclosure (Navy)
DIP	Document Improvement Program (Naval Air Systems Command)
EDMICS	Engineering Data Management Information Control System (Naval Air)
EDS	Engineering Data Systems -0009 & -0016 (Army)
FIST	Fault Isolation by Semi-Automated Techniques (SPS-46)
FLAT TOP	Technical Data Automatic Retrieval System (Army)
FORECAST	Preprogrammed troubleshooting. (Navy & Army).
HOLDOR	HOlographic Laser DOcument Retrieval System (Army)
IMP	Integrated Maintenance Plan (Navy)
JOBTRAIN	Branching Networks - HumRRO/Army
MADAR	Malfunction, Detection, Analysis and Recording (Air Force/Lockheed -C-5A)
MAINTRAIN	MAINtenance and TRAINing in Complex Equipment (NIKE-AJAX)
MDS	Maintenance Data System (Army SAFEGUARD/ Western Electric)
MEMRI	Maintenance Engineering Management & Repair Information (Republic-Hiller)

MIARS	Maintenance Information Automated Retrieval System (Navy)
MICROMS	Maintenance Information Concerning the Repair and Operations of Missile Systems (Army Missile Command)
NARF-JAXMS	Naval Air Repair Facility - Jacksonville Microfilm System
PC	Profile Cards (Philco)
PYRAGRAM	PYRAmid DiaGRAM (Hughes)
RAPIDS	Rapid Automated Problem Identification Data System (Navy)
RESTORE	Rapid Evaluation System TO Repair Equipment (Martin-Marietta)
SADIE	Smith's Aural Diagnostic Inspection Equipment (British European Airways & RAF)
SIMM	Symbolic Integrated Maintenance Manual
TMMICS	Technical Manual Management Information Control System (Navy)
TRACE	Transistor Radio Automated Circuit Evaluation (Philco)
VATE	Versatile Automatic Test Equipment (Air Force/Hughes)
WSMAC	Weapon System Maintenance Action Center (Navy/McDonnell-Douglas)

DOCUMENT SUMMARY

The purpose of this documented study was to review microfilm storage and presentation systems/equipment available and tested that could be used to reduce the bulk and increase the usability of current military/commercial technical manual systems.

Mainly, mechanical presentation systems/devices, capable of storing micro= reductions of printed technical manual pages, were covered. The basic microformat elements that must be understood and considered when selecting the optimum microfilm system/equipment for a given technical manual program were discussed. Microfilm systems/equipment, applications and tests relative to the mechanical storage and presentation of technical manual information were also revi wed. Finally, new content, format and indexing requirements applicable to microfilmed technical manual systems were critiqued. It was recommended that a separate study docume nt be prepared covering additional content, format and indexing approaches methodology pertaining to microformatted operation-maintenance information presentation systems. These new microformatted requirements were to be related to current military technical manual system criteria for comparative analysis purposes.

Two basic technical manual microfilm storage and retrieval system objectives were established. The first objective was to achieve a large reduction in the amount of space required to store the technical manual collection. Most of the operation-maintenance information microfilming studies, tests and applications reviewed achieved a 92 to 98 percent reduction in the amount of space needed for printed technical manual storage. The second objective was to establish a storage record of optimum size, shape, and storage density that could be handled rapidly and inexpensively by machines for retrieval and dissemination of the desired information. The study proved that a microfilm system represented the most reliable and cost-effective means currently available for this established purpose.

Other conclusions are as follows:

- The use of mechanical microfilm presentation devices result in a reduction in maintenance time (in most applications) and enhance the usability, integrity and timeliness of the technical manual maintenance information.

- The microfilming of existing printed technical manuals is a step in the right direction but is only a partial answer to the current maintenance information problem.

- An overhaul of the existing technical manual system requirements is needed, including improved fault isolation procedures, content, format, and indexing concepts.

- Revising of specification requirements should be done during 1970 so that job-oriented "fault-fix" maintenance information presentation systems tailored to standardized and proved microfilm systems/equipment will be available to support the complex systems/equipment of the 1970s.

- Microfilm operation-maintenance information system applications must be integrated early into the overall contractor/customer maintenance support concept for the particular system/ equipment under development.

- Satisfactory "manual" readers and reader-printers are currently available for line, shop and overhaul use.

- Satisfactory portable "manual" readers and reader-printers will soon be available for field use.

- Satisfactory "automatic" reader-printers will soon be available for maintenance information use.

1.0 NEED FOR IMPROVED MAINTENANCE INFORMATION PRESENTATION MEDIA

This section describes the rapid increase in the bulk of the printed information necessary to maintain today's complex systems/equipment. A partial solution to this technical manual problem is introduced i.e., -- the storage, random retrieval and presentation of microformatted maintenance information.

1.1 GROWTH IN PRINTED MAINTENANCE INFORMATION

As technology has accelerated, so also has the volume and bulk of the printed information necessary to maintain the new systems/equipment. Systems are bigger - - they contain more subject matter for technical manuals. Hardware design is becoming more complex - - it takes more written and illustrated material to reduce the design to understandable terms for operation and maintenance purposes.

1.2 MILITARY MAINTENANCE INFORMATION BULK PROBLEM

1.2.1

General Frank S. Besson, Commanding General, U.S. Army Materiel Command (AMC), discussed the statistical information shown on Figures 1.2.1 and 1.2.1-1 at a recent technical manual symposium (Reference 1[1]). He stated that AMC contracted for the preparation of over 300,000 different technical manual pages in 1967 and they planned to let contracts for over 500,000 pages in 1968. The Air Force and the Navy each annually require considerable more technical manual pages than those cited for the Army. General Besson stated the following regarding Figure 1.2.1-1:

> "This 150-volume library down in the maintenance company is not arranged all nice and neat in shelves, catalogued and cross-indexed. No, it is crammed in foot lockers, boxes, CONEX's, bins and chests, and when the company's on the move - - and most of them in Vietnam are - - all these things have to be loaded and unloaded, packed and unpacked, time and again."

[1] Numbers in parenthesis (i.e. Reference 1) direct the reader to the specific publication in the Reference sheets, that follows the Appendices, at the end of the document.

THE *BOEING* COMPANY

THE AMC MANUALS
LIBRARY

20,000 MANUALS

1.2 MILLION PAGES

@ $70 AVERAGE COST PER PAGE

An *84* million dollar collection!

Figure 1.2.1   U.S. Army Materiel Command Technical
Manual Statistics (General Frank Besson - 1968)

150 TECH MANUALS IN A COMPANY-SIZED UNIT

THOSE 150 TECH MANUALS EQUAL

25 linear feet,

15 cubic feet,

688 pounds . . .

or about 130,000 pages!

Figure 1.2.1-1   Technical Manuals Required For a U.S. Army
Company-Sized Unit

1.2.2

The Navy has also experienced a rapid growth in the bulk of their printed
maintenance information requirements. Figure 1.2.2 illustrates this acceler-
ated growth in the number of pages required in basic-01 series technical manuals
(air-frame and systems) for six typical Navy aircraft. Note that the C-47
aircraft required approximately 1000 pages, whereas the F-4 and A-6 aircraft
each require over 30,000 pages for organizational level maintenance.
Considerable more pages are required for each aircraft for intermediate and
depot level maintenance. However, this is only part of the bulk problem!
Another major problem is keeping the technical manuals current. Figure 12.2-1
shows the number of page changes required for typical -01 manuals in a one-
year time period. These illustrations indicate that the basic -01 manual issue
for the A-7 aircraft was approximately 7000 pages, yet in the first operational
year there were over 12,000 -01 technical manual page changes. Keeping
current the huge military maintenance information libraries has resulted in
serious problems in the areas of storage, file integrity and data retrieval time,
and in the cost to update and in the time to distribute the bulky printed material.
The aforementioned Navy technical manual statistics were extracted from a
presentation given by Cdr. G. E. Bethune of the Naval Air Technical Services
Facility at the 16th International Technical Communications Conference on
15 May 1969 (Reference 2).

1.3   INDUSTRY MAINTENANCE INFORMATION BULK PROBLEM
The growing bulk and volume of the technical manuals is not exclusively
a military problem. The non-military technical world is encountering the
same problem. Figure 1.3 shows the growth in number of pages of a typical
technical manual type from the DC-3 (C-47) aircraft era to the supersonic
aircraft era. This rapidly growing particular type of manual will be a
necessary maintenance aid for the SST and future military/commercial systems.
The commercial airlines have recognized the maintenance manual bulk problem,
and the related updating and usage problems. American Airlines, in a study of
their printed technical manual system, discovered that they required bookcase

USE FOR DRAWING AND HANDPRINT — NO TYPEWRITTEN MATERIAL

GROWTH OF MAINTENANCE INFORMATION

BASIC 01 SERIES MANUAL

PAGES IN THOUSANDS

35 — 30 — 25 — 20 — 15 — 10 — 5

Labels: C-47, A-4A/B, A-4C, A-4E, RA-5C, A-7A, F-4, A-6
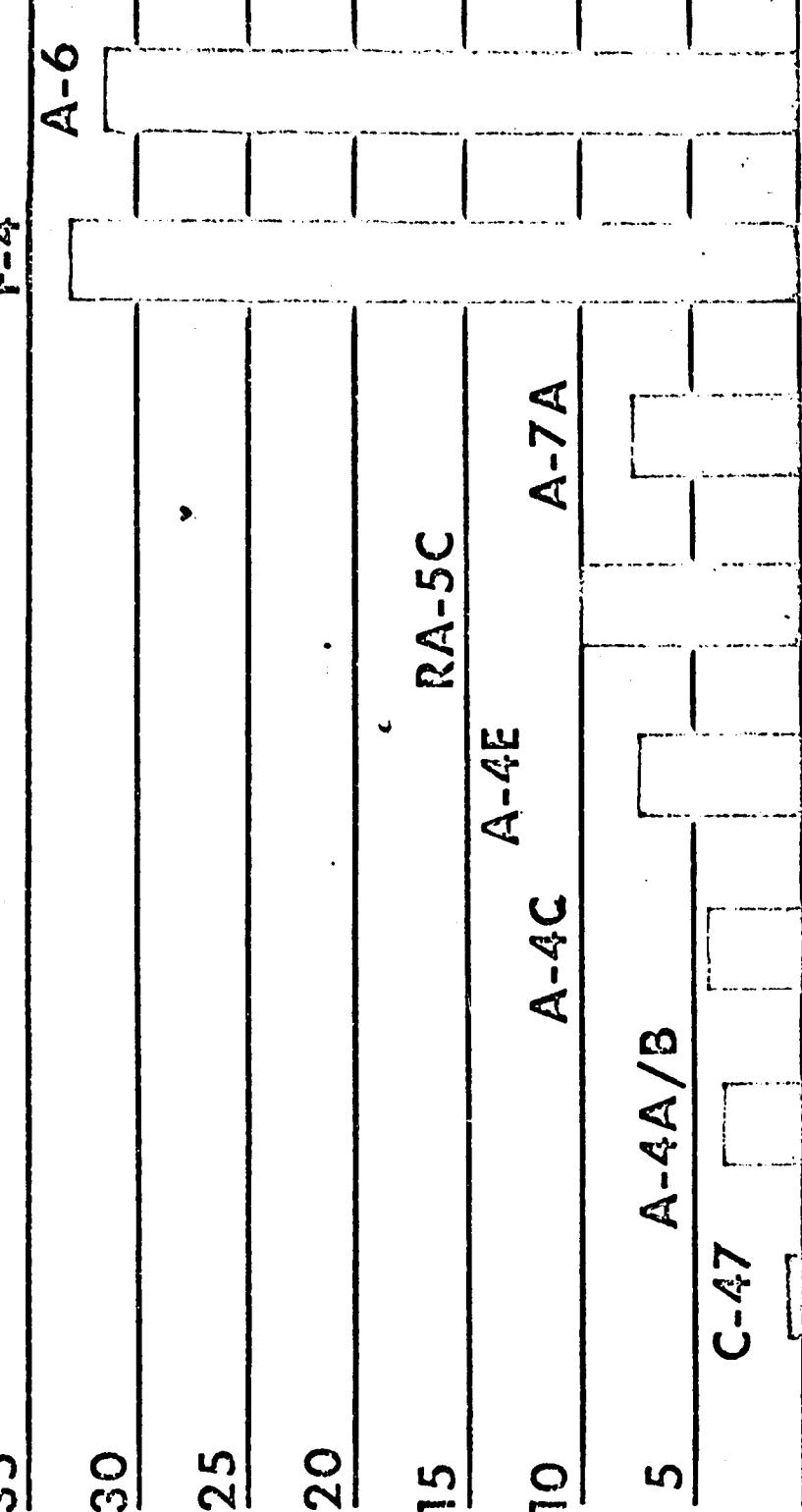
FIGURE 1.2.2   GROWTH OF MAINTENANCE TECHNICAL MANUAL REQUIREMENTS

AIRCRAFT MANUAL CHANGE/REVISIONS

1 NARF - 1 MANUAL

MODEL A/C	ANNUAL CHANGE/REVISION PAGES
A-4	12,600
RA-5C	4,100
A-7A	12,100
TOTAL	28,800

NOTE: The original issue for the A-4 aircraft -01 series technical manual consisted of 7000 pages, yet in one year there were over 12,000 page changes to subject manual.

FIGURE 1.2.2-1   TYPICAL TECHNICAL MANUAL PAGE CHANGES PER YEAR

USE FOR TYPEWRITTEN MATERIAL ONLY

┌─── NOTE ───┐
Figures shown are based on
a single customer approach.
As customers and engineer-
ing changes increase, the
total page count in the master
IPB will be substantially
greater than shown. For
instance, the number of pages
in the 707-320 IPB increased
from 4700 pages (1959) to over
30,000 pages (1967).

Pages

19,000
17,000
15,000
13,000
11,000
9,000
7,000
5,000
3,000
1,000

DC-3   DC-6A   DC-7C   DC-8F   SST
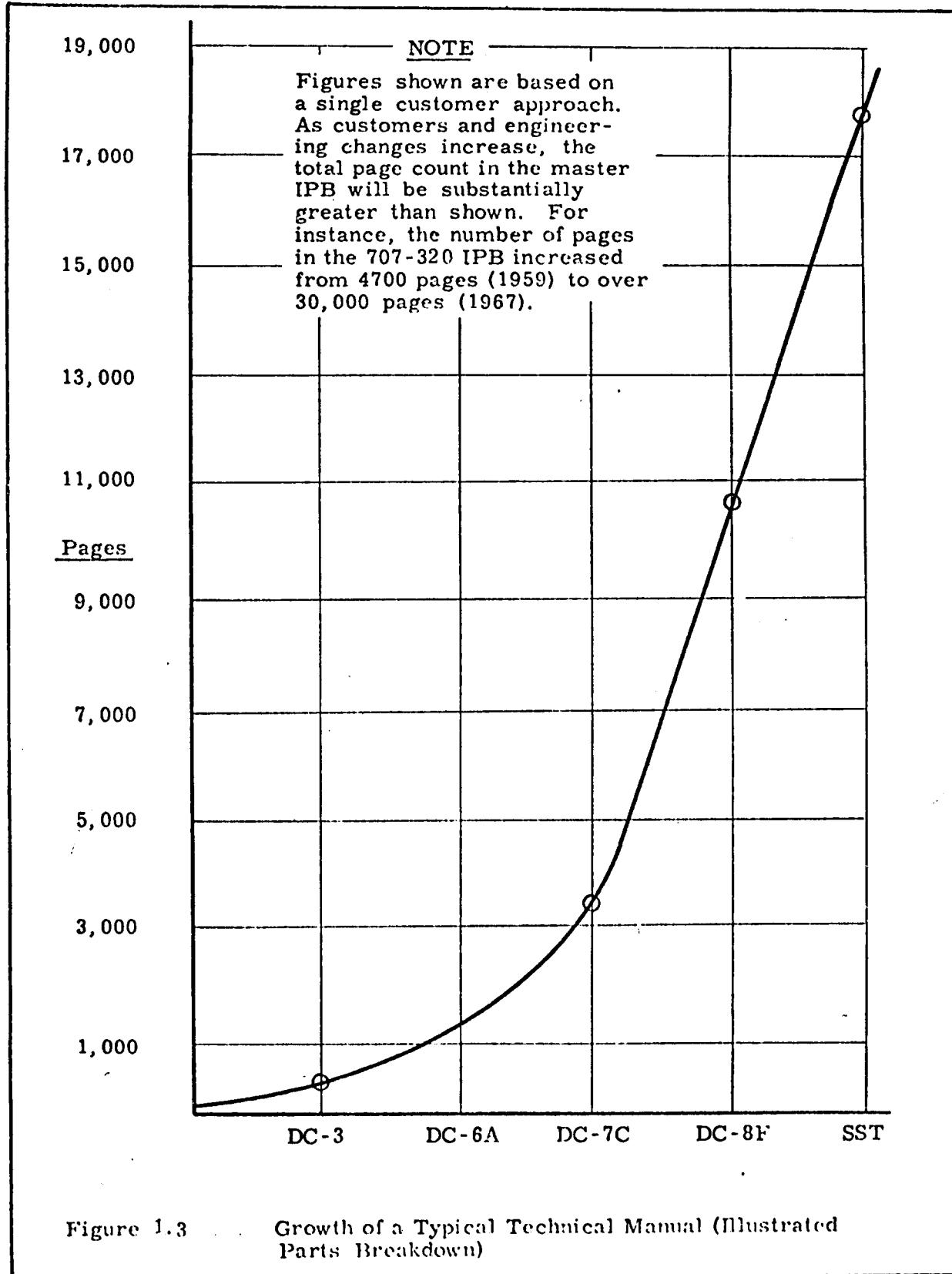
Figure 1.3   Growth of a Typical Technical Manual (Illustrated
                 Parts Breakdown)

space for over 11,400 technical manuals(Reference 3). Section 5 of this document is devoted to airline microfilm technical manual studies and applications.

1.4   THE SEARCH FOR A SOLUTION TO THE MAINTENANCE
            INFORMATION BULK PROBLEM

The sheer bulk of the printed information required to maintain today's complex systems/equipment has necessitated a search for new methods of presenting technical information. A report prepared for former President Johnson by his Science Advisory Committee titled, "Science, Government and Information" (Reference 4), identifies the problems relevant to "transferring technical information", and cites steps that should be taken to meet these problems. One of the best initial surveys of what should be done to solve the technical manual information "transfer problem" was conducted by the National Security Industrial Association (NSIA) in 1964 (Reference 5). The NSIA report stated the following relative to the aforementioned Science, Government and Information report:

"We agree with the presidential report: we believe that the increasingly urgent problems with technical manuals closely parallel those of scientific and research information. Although the President's Science Advisory Committee panel was concerned with research information, it identified the problem that confronts the printed technical manual - - increasing bulk and complexity."

1.5   A SOLUTION TO THE TECHNICAL MANUAL BULK PROBLEM

This presidential report, other studies, and the growing technical manual bulk problem have accelerated the development c. microfilm systems/equipment that store, randomly retrieve and rapidly display (and printout, if required) large libraries of printed technical information.

Today, systems/equipment are available that can store, retrieve within seconds, and display all of the operation-maintenance information required to support the most complex military system whether it be a ship, aircraft or missile. This equipment ranges from simple mechanical devices to complex electronic presentation systems.

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2.0 TECHNICAL MANUAL MICROFILM SYSTEM ELEMENTS

This section describes the basic elements that must be understood and considered in selecting an optimum microformatted operation-maintenance information storage and presentation system.

2.1 BASIC ELEMENTS OF TECHNICAL MANUAL MICROFILM STORAGE AND RETRIEVAL SYSTEMS

The following elements are involved in technical manual microfilm systems:

o Film Format   o Production Equipment

o Film Type   o Presentation Equipment

Some of these elements are hardware that is part of the microfilm system while others relate to the nature of the material handled by the system. These elements cover the significant equipment-related variables that must be evaluated when selecting components to satisfy the requirements of different technical manual microfilm system applications.

2.1.1 Film Format

Format, when used as a technical manual microfilm element, refers to the physical characteristics of the finished microform. The microfilm formats currently available include the following:

o Roll Film (8, 16, 35, 70 and 105mm) wound on a spool and often packaged in a cassette or cartridge.

o Strip Film (usually protected by acetate jacket cards)

o Sheet Film/Microfiche

o Aperture Card (mounted in a cardboard holder)

o Film Chip

o High Reduction Film Card/Ultrafiche

The film format and its size are two important variables that determine the potential of a technical manual miniaturization system and its effectiveness and convenience to the user. See Figure 2.1.1 for additional information on representative microfilm formats. The various film

** MINIMUM REDUCTION RATIO LIMITED BY A FIXED CELL SIZE (FRAME). IN CERTAIN CASES A DOUBLE CELL MAY BE USED.

TOTAL NUMBER OF MICROIMAGES, PAGES OR FRAMES	MAXIMUM ** REDUCTION RATIOS	NUMBER OF ROWS (X-AXIS) AND NUMBER OF COLUMNS (Y-AXIS)
1 SIZE OF DOCUMENT (ENGINEERING DRAWING)	12:1	1 Column 1 Row **105 MM STANDARD** FOR ENGINEERING DRAWINGS AND GRAPHIC ARTS
60 SIZE OF DOCUMENTS: (8½" x 11")	20:1	12 Columns 5 Rows **COSATI** (COMMITTEE ON SCIENTIFIC AND TECHNICAL INFORMATION) MICROFICHE
60 SIZE OF DOCUMENTS: (8½" x 11")	24:1	12 Columns 5 Rows **DOD** *** (DEPARTMENT OF DEFENSE) (AND EUROPEAN) ***MAY ALSO USE COSATI STANDARD. MICROFICHE
98 SIZE OF DOCUMENTS: (8½" x 11")	24:1	14 Columns 7 Rows **NMA** (THE NATIONAL MICROFILM ASSOCIATION) MICROFICHE
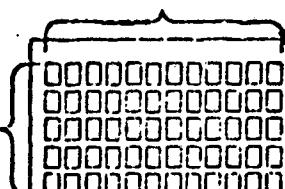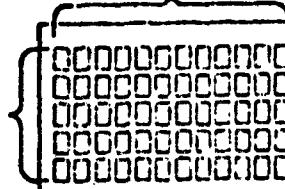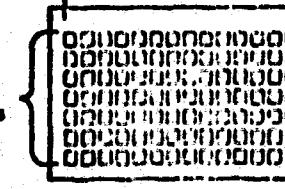
Figure 2.1.1 TYPICAL MICROFORMS

*HIGH REDUCTION FILM CARD

TOTAL NUMBER OF MICROIMAGES, PAGES OR FRAMES	MAXIMUM REDUCTION RATIOS	NUMBER OF ROWS (X-AXIS) AND NUMBER OF COLUMNS (Y-AXIS)
3200 SIZE OF DOCUMENTS: (8½" x 11")	150:1	80 Columns 40 Rows NCR (THE NATIONAL CASH REGISTER CO.) HR-FICHE*
2100 SIZE OF DOCUMENTS: (8½" x 11")	120:1	70 Columns 30 Rows NCR (THE NATIONAL CASH REGISTER CO.) HR-FICHE*
1 VARIABLE (DEPENDS ON SIZE & NUMBER OF CARD OPENINGS)	16:1	APERTURE CARD (35mm)
2100 SIZE OF DOCUMENTS: (8¹/2 x 11")	24:1	Continuous Film (16mm or 35mm) Roll & Cartridge
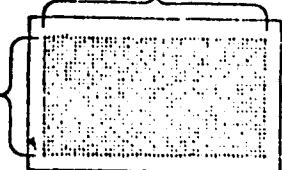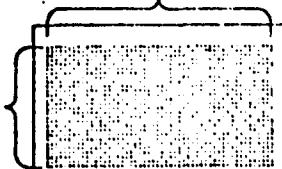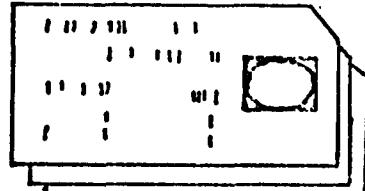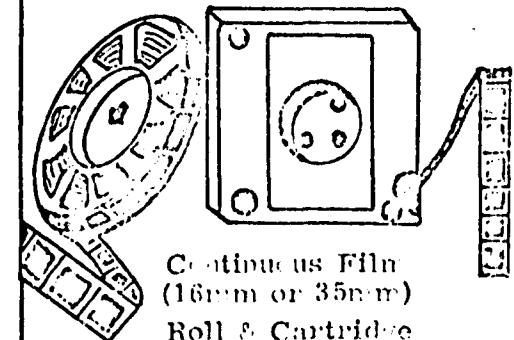
Figure 2.1.1 TYPICAL MICROFORMS

USE FOR DRAWING AND HANDPRINTING—NO TYPEWRITTEN MATERIAL

TOTAL NUMBER OF MICROIMAGES, PAGES OR FRAMES	MAXIMUM REDUCTION RATIOS	NUMBER OF ROWS (X-AXIS) AND NUMBER OF COLUMNS (Y-AXIS)
1	10:1	
1	40:1	FILM CHIP 35mm CHIP to 70mm CHIP
VARIABLE	VARIABLE	Jacketed Film & Film Strips
2000 SIZE OF DOCUMENT: ($8^1/2'' \times 11''$)	210:1	◄— 6" —► ULTRA FILM
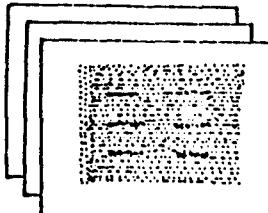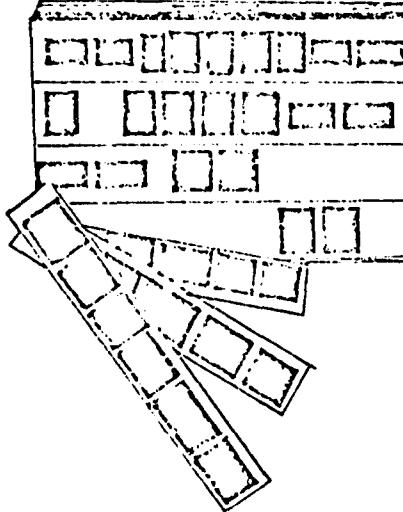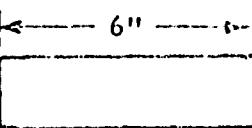
Figure 2.1.1   TYPICAL MICROFORMS

formats and related equipment, and the respective advantages of each,
are discussed in Sections 3 and 4 of this document. One final item relating to
film format that must be understood is reduction ratio.

2. 1. 1. 1   Reduction Ratio

In microphotography, the film image of the original document page is greatly
reduced in size and cannot be read by the naked eye. This reduction depends
on the size, detail, and contrast of the material printed in the original
technical manuals and on the legibility desired in the film copies. The
size of the microimages, as compared with the size of the original document,
is expressed in terms of diameter, or reduction ratio. For example, when
a reduction ratio of 19 to 1 (commonly expressed as 19:1 or 19X) is used,
it is possible to reduce an 8 1/2-inch technical manual page, measuring 19-inches
in length, to 1-inch of 35 mm film. More images can be recorded on the same
amount of film by using a higher reduction ratio. Thus, the reduction ratio
is a significant measure of the storage capacity of a microfilm system. It is
also a significant factor in blowback, equipment (optic) design and readability
in viewing.

2. 1. 1. 2   Reduction Ratio Parameters

The following parameters affect the reduction ratio:

a.   Resolving Power of the Eye

      For error-free reading of print at normal viewing distances, it has been
      found that the resolving power of the human eye is about 6 to 12 lines
      per millimeter.

b.   Resolving Power of the Film

      Specification MIL-M-9868 states that a resolution of 100 to 120 lines per
      millimeter is acceptable for microfilm recording at reduction ratios
      of from 16 x 30 x. The average Kodak microfilm emulsion has a
      resolution of approximately 250 lines per millimeter. Film may be
      tested as follows:

If a film emulsion has a resolving power of 100 lines per millimeter or greater, and a National Bureau of Standards Resolution Test Target is contact-printed on it, and developed under laboratory conditions, then it is possible to discriminate, through a standard microscope, the lines of the test pattern containing 100 lines per millimeter (or greater). Test target patterns are usually placed on the last frame (image) of a microfiche (or roll film) for quality control usage.

c. Number of Successive Regenerations Required

Microfilm document storage and retrieval systems do not circulate their original negatives to users. Thus, duplicate working file is usually made from diazo film stock. From the diazo working file, either duplicate microforms are made or hard copy is printed and disseminated. Thus, the user will usually be working with a third-to-fifth-generation reproduction of the original technical manual. Air Force conducted microfilm studies have indicated that each successive regeneration of a film retains an average of only 80 percent of the resolution measurable in the previous generation. In other words, if a master negative is made with a resolution of 100 lines per millimeter, the diazo working copy will contain only 80 lines per millimeter of the original data, and the dissemination copy will retain only 64 lines per millimeter of the original information. This is important relative to microformatted technical manuals, since the user will be using a fourth or fifth generation copy. Thus, one may generally conclude that the reduction ratio for micro-formatted technical manual pages should not be greater than 24:1. Under these conditions, it will be possible to obtain fifth generation copies that are of adequate quality to permit error-free reading.

d. The Resolving Power of the Optical System

The final factor affecting the reduction ratio is the resolving power of the optical system. The theoretical optical limit for such systems is in the vicinity of a reduction ratio of approximately 600:1. However, there are other factors one must consider. Although a technical manual system may be used under conditions wherein successive regeneration

of document images is not a limiting factor, there are problems with
increasing reduction ratios relative to the film transport mechanisms
in the cameras and readers. Also, printers become too complicated.
The greater the number of images stored within a given area of film,
the more difficult is the problem of indexing, locating, and accurately
registering a single frame (or page). The cost and complexity of the
image-registration mechanism currently discourages the use of higher
reduction ratios for technical manual programs. This was proven in the
Air Force PIMO program which initially employed MICRO-VUE readers
with a reduction ratio of approximately 260:1 (paragraph 4.4.3). The
MICRO-VUE readers were subsequently replaced with Audiscan audio-
visual (16mm) units (paragraph 3.4.7) which use a reduction ratio of
approximately 24:1.

2.1.2   Film Type

Film is the basic information storage medium. Microfilm is a photographic
image-recording material of high resolution, usually in 16mm or 35mm sizes.
Some special applications also utilize 8mm, 70mm and 105mm film. A number
of emulsions, such as silver halide, Diazo, and Kalvar are also available, and
are used at different places in various systems where their respective
properties are of advantage. Microfiche is simply a roll of 105mm cut at
6-inch intervals.

2.1.3   Production Equipment

Two major items of equipment required in microfilm technical manual systems
are cameras and the film processors. The camera is the device used for
imaging technical manual pages on microfilm and the film processor is the
means for developing the film and fixing the image permanently on the storage
medium.

2.1.3.1   Microfilm Camera Types

The two basic microfilm camera types are:

a. <u>Rotary Camera</u>

The rotary camera derives its name from the rotating drum over which input technical manual pages are fed to be photographed. It differs from the planetary camera in that the pages are in motion while it is being filmed. When a page is inserted in the machine, its leading edge actuates a tripping mechanism that turns on the camera lights and starts advancing the film. The rotation of the page and the film advance are synchronized; the image is automatically exposed on the moving film through a slit as the page passes directly in front of the camera aperture. The reduction ratio of the lens is also geared to the film-advance mechanism; thus, more film is exposed for a document being photographed at 17:1 than the same document being photographed at 30:1. Some rotary cameras photograph only one side of a document at a time, while others photograph both sides of a document simultaneously. By equipping the cameras with automatic feeding devices to expedite document input and transport, approximately 300 technical manual pages can be filmed per minute. By the hand feeding method, approximately 40 to 60 technical manual pages may be filmed per minute. The rotary camera advantages are ease of operation and the speed with which the pages can be copied. Its big disadvantage is that it is not suitable for precision microfilming. Thus, rotary cameras are not recommended for high reduction ratio miniaturization systems such as ultrafiche.

b. <u>Planetary Camera</u>

The planetary camera is often called a flat-back or over-head camera. This is the best equipment for microfilming materials requiring high quality reproduction. The technical manual page to be filmed is placed on a flat copy table. The camera is mounted on a column or arm extending over the technical manual page. If the size of the page image on the film is to be increased, the camera is raised; if the image size is to be reduced, the camera is lowered. This is in contrast to the rotary

camera which requires different lenses to change the reduction ratio. The primary disadvantage of the planetary camera is the relative slowness with which technical manual pages may be filmed.

2.1.3.2 Step-and-Repeat Camera

A step-and-repeat camera is recommended for technical manual microfiche systems. The microfiche format is a rectangular sheet of film containing document images (pages) arranged in regular rows and columns. Figure 2.1.1 shows several of the microfiche types that are currently available. These contain up to 98 8 1/2 x 11-inch technical manual pages that may be arranged in various formats, as described in Appendix A at the rear of this document. The best way to prepare microfiche technical manual pages is to photograph them on 106mm film (4.1-inches wide) by means of a camera that will transport the film magazine in a step-and-repeat fashion until it has sequenced through the required rows of frames (pages) before advancing the film another 6-inches. The first "header" row contains identification data (Figure 5.4.2.2). Secondary microfiche are usually identified only by number in the first two frames of the first row. The last two frames usually contain the date and resolution target patterns. Microfiche masters may also be made by compositing and pasting-up 16 or 35mm strips of film. This is called a microfolio microfiche. However, the step-and-repeat camera that does the job of composition and placement as it exposes the master microfiche is recommended. The step-and-repeat capability is available on both rotary and planetary cameras.

2.1.3.3 Film Processors

Once the film has been exposed, the film must be processed. Film processors of various types are available. For large technical manual microfilm applications, fully automated film processing equipment is recommended that incorporates built-in automatic quality control test features. Semi-automatic and manual film processing systems are also used. Various types of film processors are described in Sections 3 and 4.

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2.1.4   PRESENTATION EQUIPMENT

2.1.4.1   Readers

Once the printed (or pasted-up) technical manual pages are microfilmed, a
reading device is required to complete the system. A reader (or viewer)
consists essentially of a microfilm holder, a lens system for enlargement of
the image, a screen for viewing the enlarged image, and controls for
focusing the image and for selecting the correct image or an enlarged portion
of a image. Readers are designed to handle roll film, aperture cards and
microfiche, or any combination of microforms. Readers may have fixed
magnification ratios or variable magnification, variable illumination, and
multiple focusing controls.

2.1.4.2   Printers

The function of the printer is to provide enlarged hard copies of microimages
for immediate use. Many readers are combined with printers and are called
reader-printers. The reader allows the user to inspect the microform
before it is printed to be sure that he is getting what he desires. The printer
records the image from the microform on paper stock and ejects the printed
material. Paper stock may be in sheets or on rolls. Printers employ various
printing methods including wet electrostatic, electrochemical, and dry-photo
processes.

2.1.4.3   Microfilm Files

The final element of a microfilm storage and retrieval system is the film
store. This is the storage unit(s) for housing the microforms. This may
consist of filing trays or cabinets designed to permit rapid retrieval of the
individual microfiche or film cartridges. For large systems, motorized
rotary files may be employed.

2.2   INTEGRATING THE MICROFILM SYSTEM ELEMENTS

2.2.1   Figure 2.2 shows the basic elements that one must consider in developing a technical manual microfiche system. (See Figures 3.4.10 and 5.4.1 for comparable roll film systems and Figure 5.4.2 for a typical microfiche "jacket" application.)

2.2.2   The elements selected and the order in which these appear may vary depending on the needs of the particular system. A system analysis should be conducted to determine what various elements should be selected and how the steps should be sequenced and integrated for optimum results.

2.2.3   Indexing in a microfiche system, as shown in Figure 2.3, refers to "eye-readable" information located on top of each microfiche (See Figures 5.4.2.2 and 5.4.2 for typical "indexing" examples). The index is added before the master is duplicated. Coding is distinguished from indexing in that coding is used for automatic retrieval and requires that a metal coded strip be added as done in the CARD System, or notches or alphanumeric codes be placed on each microfiche. In roll film systems, indexing coding approaches are more complex and are described in paragraph 3.3. Storage refers to the physical container in which the duplicate microfiche is placed. These containers may range from a file drawer or cabinet up through highly sophisticated equipment.

2.2.4   Note in Figure 2.3 that three types of film may be used for duplicating microfiche - silver, vesicular (Kalvar), and Diazo. All are available in negative and positive forms and all require that the master be brought into close contact with the unexposed duplicate film. After exposure to light, the duplicate film is processed.

2.2.5   After processing, a major requirement is a complete film inspection to verify the page order, focus and density of all images. An inspection also must be performed after the duplicate microfiche has been developed.

USE FOR TYPEWRIT MATERIAL ONLY
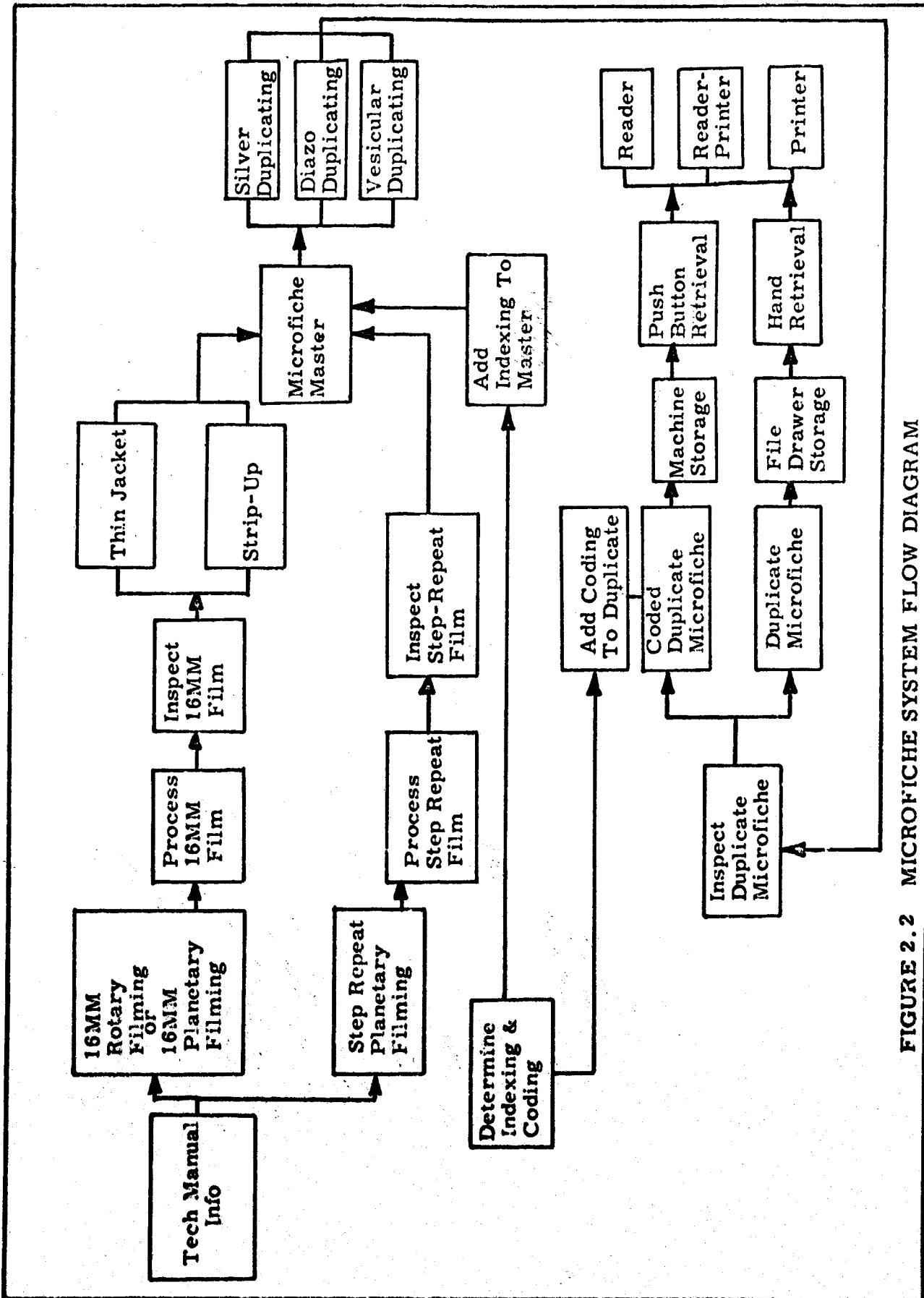
FIGURE 2.2 MICROFICHE SYSTEM FLOW DIAGRAM

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2.2.6   Finally, note that the retrieval and storage of microfiche are not really separate functions since the container in which the microfiche is stored has a direct bearing on the ways in which it may be retrieved. Retrieval will depend on the earlier decisions of whether to index, in which case human fingers may be the retrieval device, or to code, in which case the push of a button might display the desired image chosen from a number of microfiche or roll film(s). For additional information on designing a microfiche system, refer to Reference 9.   (References are listed on Reference Sheets, following the Appendices, at the end of the document).

3.0   ROLL FILM MICROFILM SYSTEMS/
EQUIPMENT

3.1   INTRODUCTION

This section describes a number of roll film microfilm systems/equipment
and applications relative to the storage and presentation of technical manual
information.

3.2   SYSTEM/EQUIPMENT EVALUATION
APPROACH

The evaluation approach employed consisted of a review and synthesis of
the results of all available military and commercial technical manual
microfilm tests and studies, technical society presentations and equipment
manufacturers' brochures. Also, numerous manufacturers' representatives
were interviewed and in some cases, visits were made to the manufacturer's
facilities. See Appendix C for a listing of vendors contacted. Appendix D
lists organizations and individuals active or interested in microformatted
technical manual approaches and improved maintenance information
presentation systems.

3.3   ROLL FILM INDEXING CONCEPTS

3.3.1

A variety of indexing techniques are used in roll film microfilm systems. The
indexing types generally fall into two retrieval categories; visual scanning
and automated. Automated retrieval requires coded information on the film
adjacent to each image or frame that can be detected by the retrieval unit
when commanded. Scanning retrieval relies on the operator to visually
locate the desired data. Scanning retrieval may involve nothing more than
using the technical manual's table of contents or index. Other visual
retrieval techniques consist of relating the indexed information to a location
on the film by odometer number or by synchronizing distinguishable horizontal
or vertical line markings on the margin of each page (or image) with a
marked scale on the side of the viewing screen.

3.3.2

Figure 3.3.2 shows four widely used methods of retrieving microfilmed (16/35mm) technical manual information. The first is the Kodak-Recordax MIRACODE system which is an acronym for Microfilm Information Retrieval Access Code. This is done by electronic eyes reading binary bits placed beside each technical manual page (frame) on the microfilm. The second method called <u>Image Count</u>, is also done by electronic eyes reading three binary bits at the bottom of each page (frame) on the film. This is a sequential count and has the disadvantage of necessitating the placement of all revisions at the end of the film or refilming the entire roll. The Image Count system is used in the Grumman A-6 aircraft RAPIDS technical manual microfilm system (Paragraph 3.4.4.2.2). The MIRACODE system is used in the McDonnell-Douglas Weapon System Maintenance Action Center (WSMAC) that encompasses a new approach relative to the storage and retrieval of microfilmed F-4 aircraft technical manual information. The third method called <u>Line Count</u>, is read with the naked eye by matching special technical manual page horizontal lines (or bars) with a scale on each side of the viewing screen as the film passes by. The fourth method is the <u>Odometer</u> which counts inches of film or frames. Other aspects of these retrieval systems are discussed and illustrated in connection with the various roll film systems and equipment described in the following paragraphs.

3.4   ROLL FILM SYSTEMS/EQUIPMENT

3.4.1   Introduction

The roll film systems/equipment and applications described in this document are typical of those currently available that could be employed in technical manual microfilm systems. For additional comparative information on the systems/equipment cited in this section and other available equipment, refer to the microfilm equipment charts in the Appendix.

MIRACODE (RECORDAK) SYSTEM
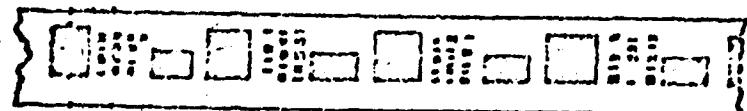
A typical MIRACODE search operation follows:

1. SELECT THE FILM MAGAZINE	2. INSERT MAGAZINE IN THE READER
3. KEY IN THE SEARCH QUESTION	4. DEPRESS THE SEARCH BUTTON
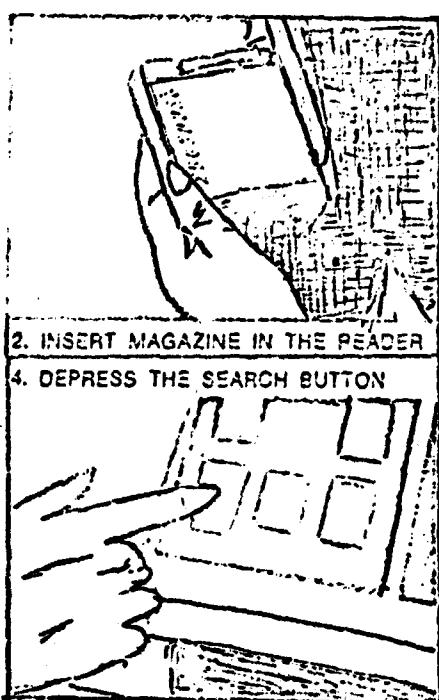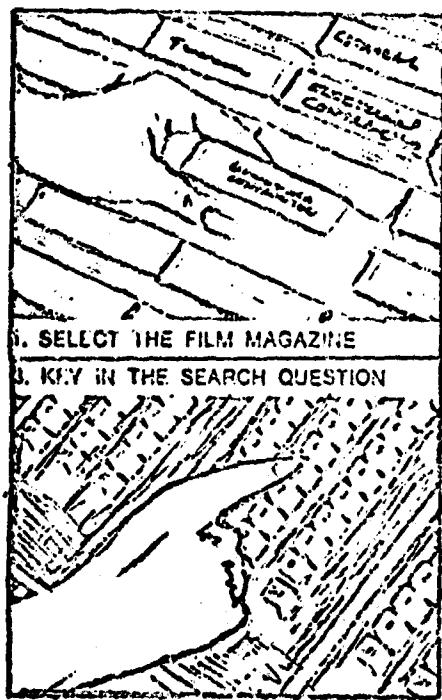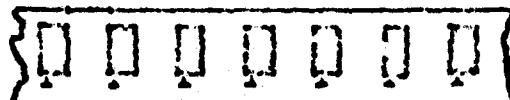
IMAGE COUNT SYSTEM   LINE COUNT SYSTEM
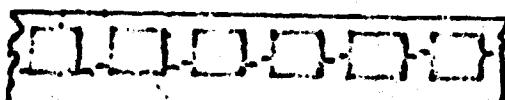
ODOMETER SYSTEM

FIGURE 3.3.2 ROLL FILM RETRIEVAL SYSTEMS

3.4.2   MAST Maintenance Information Display Devices

3.4.2.1   MAST 35mm Random Access Projector System

The Mast Development Company of Davenport, Iowa produces 35mm filmstrip Random Access Projectors (RAP s) with a capacity of 100 to 500 frames. These projectors, when combined with a rear projection screen and control panel, form a complete projector viewer system which can be mounted in a standard 19 inch rack or cabinet. This projector system, when commanded, automatically locates and projects any one of 500 frames in a few seconds. Two of these projectors can be mounted in adjoining standard 19 inch racks in a cabinet or in a bulkhead as shown in Figure 3.4.2. Using two projectors permits the maintenance man to compare text with the corresponding illustration. Thus, the valuable text-to-illustration comparative relationship advantage of the printed technical manual is not lost.

Individual frames of color or black and white film may be selected at random or in forward or reverse sequence with this compact projector system. Pictures are projected on the panel-mounted rear projection 10 x 15 inch screen. The control panel is on the front of the easily accessible drawer-type projector system housing. A "short-way home" film search is a feature. A servo drives the film in either forward or reverse direction as required to make the shorter and therefore faster approach to a requested frame. Thus, film transport is always directly from the frame being projected to the new frame without returning to a reference point. Frame selection in RAP projectors is not limited to random use of manual switches. A relay buffer circuit may be substituted for the manual switches and individual frame selection made directly by computer command.

Film loops are made from conventionally prepared filmstrips. Acetate base film may be cemented or taped into a loop. Longer life polyester base film is also available. Mast projectors are used in the NASA Saturn V and other maintenance information presentation programs.

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NOTE: The Blocked Schematic Diagram and Blocked Text are being displayed simultaneously.
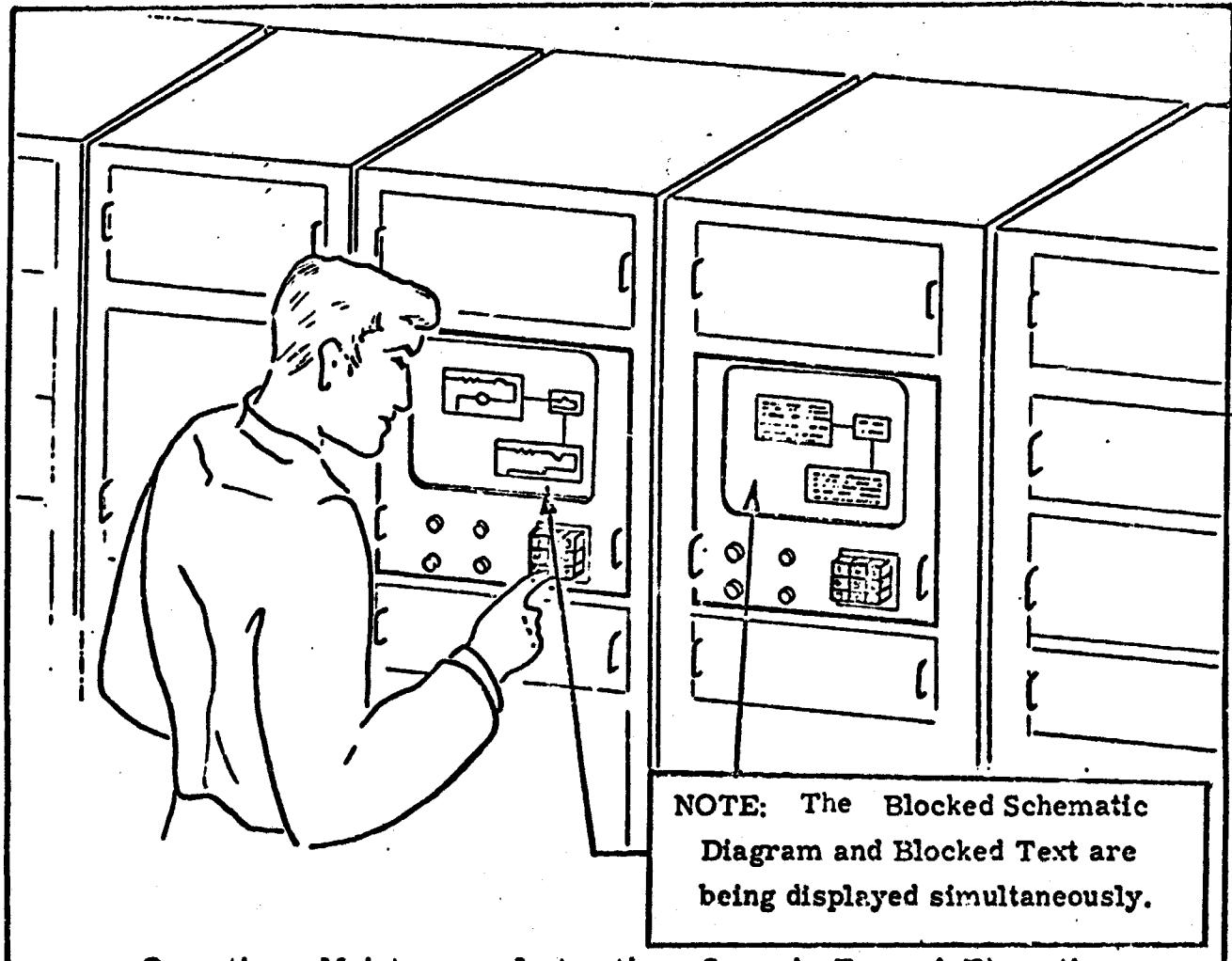
Operation - Maintenance Instructions Seconds From A Fingertip

10 x 15-inch Screen

Two Mirrors Form "Z" Shaped Projection Path

Keyboard

Closed Loop Film System
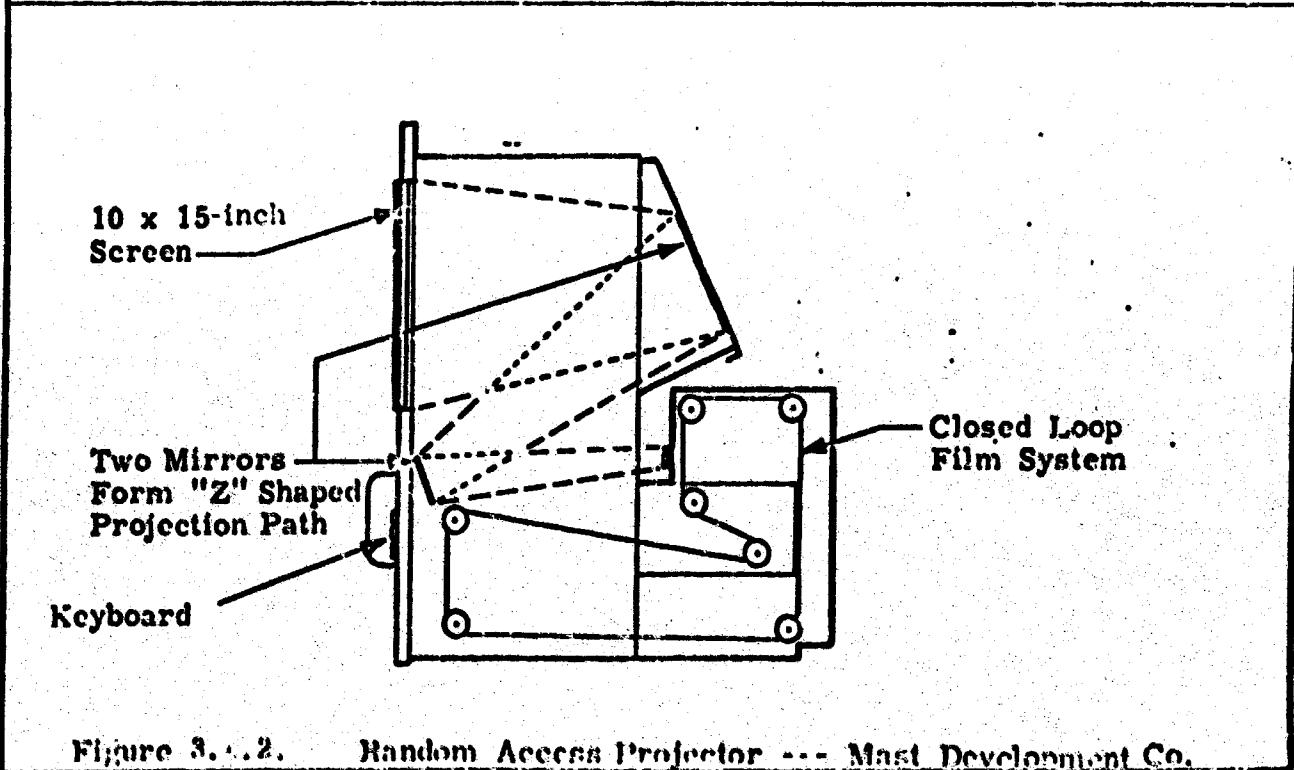
Figure 3...2.   Random Access Projector --- Mast Development Co.

THE *BOEING* COMPANY

3.4.2.2   MAST Programmed Instruction 35mm
Display Device

The MAST Development Company also produces a variety of compact, portable and low cost display devices (and teaching machines) that are widely used in government, industry and schools for linear programmed instruction (PI). This PI approach has a great potential relative to the presentation of maintenance instructions. The employment of these and similar units (see paragraph 4.5.7.3) will necessitate the merging of several of the Integrated Logistics Support (ILS) elements (maintenance analysis, training and technical publications). This has been a goal for the past decade but has not been successfully accomplished in any program. The employment of these simple, mechanical PI devices can bring about this needed "merger" since in order to develop a successful "program" the following must be accomplished:

    a. Conduct a thorough maintenance analysis covering "total" maintenance support, training and other customer requirements.

    b. Program the maintenance instructions per personnel task, equipment and other requirements.

    c. Employ display devices and maintenance instructions in training programs in order to de-bug and validate the procedures.

    d. Use publications engineers to assist in the preparation of maintenance analyses and training instructions, as well as for the preparation of the final programmed maintenance instructions that will be used by the customer.

The MAST devices shown in Figure 3.4.2.2 can be used to present operation and maintenance instructions as well as maintenance training information. They operate on the self-contained projector principle, with a 4" x 6" viewing screen. Machine options include regular, stereoscopic, or tachistoscopic program presentation, as well as facility for separate audio, timer or other auxiliary equipment control. A mechanism that automatically advances a paper tape for written responses is also optional.

U S 4802 1434 REV . 8-65

Weighs 11 Pounds

Cartridge Holds Up to 800 Frames In
Four Sequences

4 x 6-Inch Rear Projection Screen

"Advance" And "Answers" Buttons

Written
Response
Paper Tape
(Optional)
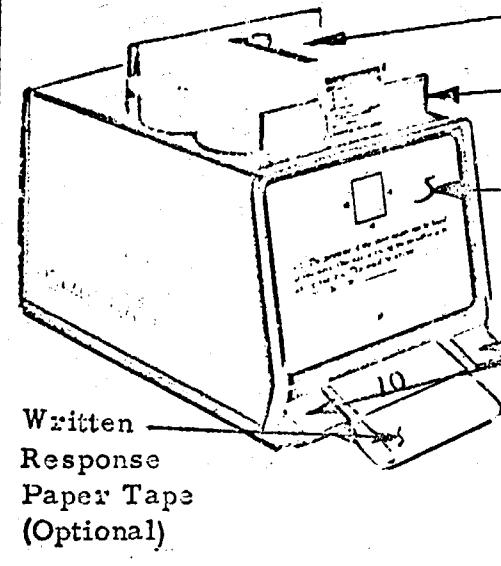
TYPICAL PORTABLE UNIT

FILM STRIP ARRANGEMENT

● Each Cartridge Holds
2 Strips of 35mm Film

● Each Strip has 2 Sequences
of 200 Frames Each
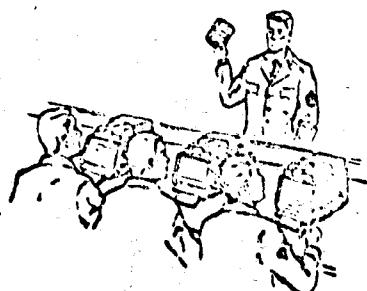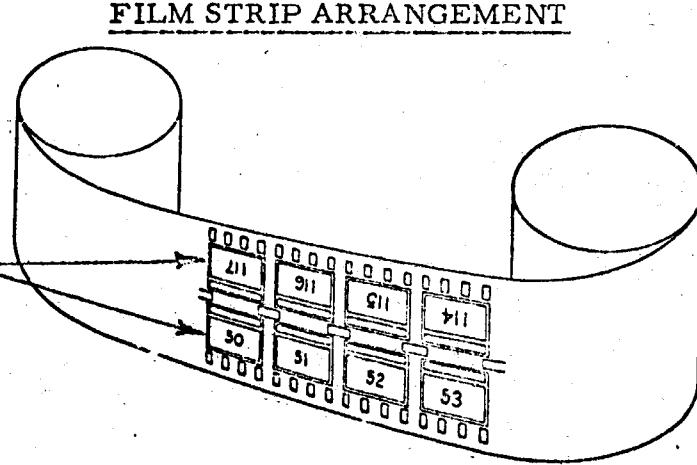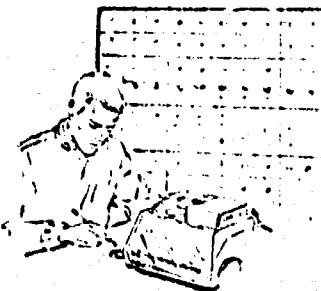
Classroom   Shop   On-The-Job Training

MAINTENANCE INSTRUCTION APPLICATIONS

FIGURE 3.4.2.2 MAST PROGRAMMED 35MM DISPLAY UNIT

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Programs used with the machines are on durable film in protective plastic cartridges. A cartridge can be placed quickly and easily on the device for viewing.

Programs for any maintenance application are easily prepared for filming by using low cost frame layout forms supplied by Mast. Guide lines printed on each form show exactly where to place the text or illustration material. Original text can be typed directly on the forms and the illustrations inked or pasted in place. Or, printed text of existing programs can be trimmed to size and pasted on the forms (Reference 62).

This simple and unique method of cartridging program materials is a major breakthrough for   presenting maintenance instructions. You get the benefits of film without the traditional disadvantages of film handling and loading. Filmed programs eliminate the need for cumbersome technical manuals. The film is protected from the user's hands by the durable plastic cartridges and may be reused a thousand times. Compact cartridges conserve storage space too. Each cartridge holds up to 800 frames in four sequences and comes in an individually marked box for library-type storage.

U.S. 4802 1494 REV. 8-65

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3.4.3   Kodak Technical Manual Microfilm Applications

Figure 3.4.3 shows three typical Kodak reader-printer and indexing combinations that have been successfully used in technical manual microfilm applications. The Image Control and MIRACODE indexing concepts were briefly described in paragraph 3.3.2.

The Image Control keyboard shown with the Kodak-LODESTAR reader-printer in Figure 3.4.3 is an electronic microfilm retrieval control device that permits rapid and automatic image (page) retrieval in response to keyboard input of a specific image/frame number. This indexing system requires a rectangular target (pattern or blip) to be exposed under or adjacent to each technical manual page photographed on either 16mm positive or negative film. In operation, when the image count reaches an exposed rectangle of a predetermined number of images ahead of the pre-selected image, reader film speed is automatically reduced. Film motion stops when the selected image (blip) is reached. A single image advance or return and a manual advance and return are also provided. Kodak provides "Image Designator Mark" equipment with their microfilmers (cameras). This electro-mechanical device is used during the microfilming process to place the required blip adjacent to each image (page).

The MK 142 Module Test Set and the F-4 WS Maintenance Action Center applications shown in Figure 3.4.3 and their distinctive indexing concepts are described in the following paragraphs.

3.4.3.1   MK 412 Test Set 16mm Microfilm Application

The MK 412 Module Test Set, an automated and self-checking module testor, was designed by General Electric for the Polaris Fleet Ballistic Missile weapon system. All machine instructions are recorded on punched tape.

All operator instructions are stored on 16mm film and displayed in a Kodak-Recordak reader (Visual Instructor) as shown in Figure 3.4.3.

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Machine Test
Instructions on
Punched Tape
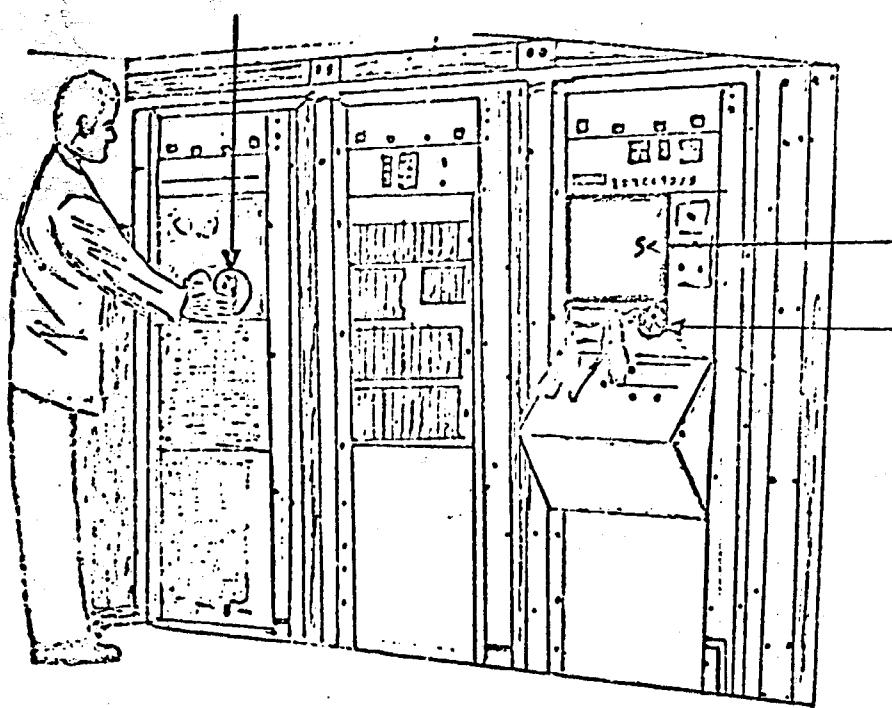
Visual Instructor
(Recordax-Viewer)

Operator Instructions
Stored on 16mm
Film

GENERAL ELECTRIC MK 412 MODULE TEST SET
(Polaris FBM Weapon System)

Reader-
Printer

Control
Console

Microfilm
Storage
File

Reader-Printer
Control Console
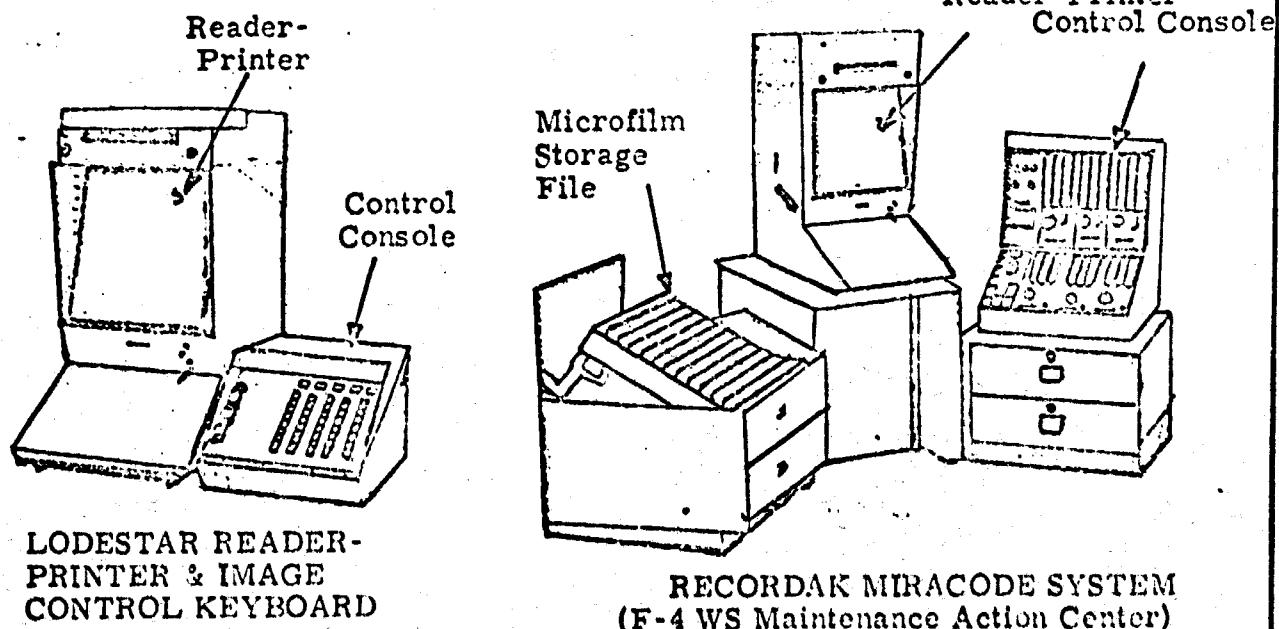
LODESTAR READER-
PRINTER & IMAGE
CONTROL KEYBOARD

RECORDAK MIRACODE SYSTEM
(F-4 WS Maintenance Action Center)

RECORDAK, MIRACODE & LODESTAR are registered trademarks
of the Eastman Kodak Company.

Figure 3.4.3 TYPICAL EASTMAN KODAK MICROFILM APPLICATIONS

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In the automatic mode, the operator installs the 16mm film, program tape reel, switching card and module, dials the module key code and tape search number, applies power and initiates the test sequences.   The MK 412 test set stops whenever a module fault is indicated, permitting the operator to either troubleshoot the fault, by-pass the failed test, or put the module aside for repair.   Where manual response is indicated, complete instructions are displayed on the Visual Instructor reader screen.

The Visual Instructor microfilm reader is also used for self-checking the MK 412 test set.   A secondary standard module is used with verification and calibration tapes and 16mm operator instruction films for the checkout, adjustment and calibration of the test set (Reference 7).   The first part of the microfilm provdes general information, performance test tables, and repair procedures for over 200 types of Data Processing and Display Subsystem component boards.   The latter portion of microfilm provides general information and diagnostic performance test tables for the test set. Over 200 test tapes and over 20 test set test tapes are used with the information on microfilm.

This microfilm reader coupled with a tape operated automated test set has been successfully used for years on Polaris submarines and sub-tenders. This coupled test set-reader approach is emphasized since it appears to be one way future systems will go.   Reader-printers with maintenance instructions will supplement the automated systems with their built-in and supporting test equipment.

The MK 412 system reader uses the "Line Count" microfilm retrieval system (paragraph 3.3.2).   The "Line" retrieval technique is also used. The MK 412 test set does not employ a "total" maintenance information microfilm approach since many printed technical manuals (Calibration Procedures,

US 4802 1431 REV. 8-65

Cross Reference List, Test Set, (5 volumes), Verification Procedures, etc.)
are required during its use.

3.4.3.2   Kodak MIRACODE Microfilm Retrieval System

Figure 3.4.3 shows the three basic items (reader-printer, control console
and access file) used at a typical MIRACODE high-speed retrieval station.
Since this system has been successfully employed in a number of new
maintenance information presentation systems, its equipment and advantages will
be briefly described before considering the MIRACODE applications.

MIRACODE stands for Microfilm Information Retrieval Access Code.
MIRACODE is a simple to operate maintenance information retrieval tool
that can out-perform the computer in the efficiency of its retrieval,
graphic display, and "on-command" printout functions.

The basic access unit of the MIRACODE System is the standard 4 x 4 x 1 inch
16mm magazine. Inside each magazine is 100 feet of film, on which are
reproducible images of the technical manual pages and, adjacent to each,
an identifying code pattern as shown in Figure 3.3.2. Each retrieval station
may store scores of these magazines (that each contain over 2000 8-1/2 x 11 inch
pages) in a microfilm file adjacent to the reader-printer. The entire file
can be readily organized into categories with a group of color-coded magazines
for each category. Then, within each category, the individual magazine
becomes the basic storage unit as well as the access unit.

Another MIRACODE file access advantage of great importance to a rapidly
changing technical manual microfilm program is the ease of file revisions.
Since it is a random access system, the retrieval equipment locates the
technical manual page requested no matter where that page appears on the
100 foot roll film - beginning, middle, or end. In view of this advantage,
each magazine is open-ended and can be added to in a random fashion. Because

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of the compactness of this film magazine filing system and its low-cost reproducibility, the possibilities for file transport, exchange, and concurrent searches at several retrieval stations are unlimited.

The code, indexing plan, and the recording of both code and technical manual pages must receive careful consideration in designing a rapid retrieval technical manual microfilm system. In reviewing the Navy WSMAC and the Army EDS maintenance information MIRACODE applications in subsequent numbered paragraphs - - - - well conceived technical manual/maintenance information indexing plans are examined. If one has a good indexing plan, there are no limitations in organizing the input to the MIRACODE system.

Each page image (or group of pages) on the film are assigned an identifying code field comprised of one or more code columns. The basic access to the code field is the individual code column. Thus, the indexing plan can be designed to employ from one to 15 (or more) columns, singly or in combination, for any type of indexing. Each code column can basically depict, by the use of 12 bits, any three digit number, 0 through 999. Or, each column can be arranged to depict numbers 0 through 1999 . . . by the use of a special "utility" bit available in each code column. One more additional bit - the parity or "checking" bit, completes the total of 14 bits in every code column. Code columns in combinations can be arranged to provide fixed and open code fields.

The MIRACODE system offers three input modes: a basic manual system and two automated systems - tab card and cathode ray tube recording. Regardless of the equipment used, the input function is to expose two types of images on the microfilm: a reproducible image of the technical manual page and an image of the identifying code field (Reference 8).

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The heart of the MIRACODE retrieval station is the Kodak LODESTAR reader-printer. The reader-printer combines high-speed information retrieval with fast, push-button production of enlarged (8-1/2 x 11-1/2 inch) paper facsimiles of the microformatted technical manual pages. The unit has a 13 x 13 inch non-glare screen. Reduction ratios of 23:1 are used by the reader and 21:1 by the printer. The printer uses 150 foot rolls of 8-1/2 inch paper and a mono bath-type processing solution that can be used for one week or 150 prints.

The modular control console houses two different types of control panels: a single keyboard control unit and a set of retrieval keyboards. All the basic functions of the system are at the finger-tip control of the operator at the keyboard control unit. And, all the search operations are performed by push-button simplicity on the retrieval keyboards. The modular concept, along with a choice of types of retrieval keyboards, permits flexibility in the type of search operations to be performed, as well as permitting opportunities for system expansion.

3.4.3.3 McDonnell-Douglas F-4 WSMAC Microfilm System

The WSMAC maintenance information concept was developed by McDonnell-Douglas. It currently is being tested on Navy F-4 aircraft. This concept portrays maintenance actions and technical data on 16mm microfilm. The name Weapon System Maintenance Action Center (WSMAC) is based on the fact that a Maintenance action center, using the MIRACODE retrieval system, serves as the focal point for all organization level maintenance tasks associated with the F-4 weapon system (References 9 and 10).

WSMAC provides complete maintenance information visually or on printed
pages that can be used at the job sites. All information pertinent to the
maintenance task is in the technician's hands seconds after the request
or inquiry. Codes (compatible with the military work unit codes presently
in use for maintenance/materiel accounting) set into the keyboard, permit
the retrieval of the requested maintenance information in seconds. Operation
of the system is as simple as most vending machines and requires no special
operator.

Maintenance inquiries by system, sub-system, component, maintenance
task, part number of malfunction (symptom) can be immediately viewed, and
upon demand,printed for job-site use. Format is compatible with work
reporting systems allowing the simultaneous issue of directives and reporting
documents. Upon maintenance task completion, the filled-in work sheets
are easily placed into the accounting system. Procedures pertinent to
certain facilities or situations (local directives) can be included and coded
so that they also become a part of the complete data package provided the
technician.

When malfunctions or symptoms are reported or known, WSMAC provides
logic tree type procedures for fault isolation and provides complete
instructions for the defined maintenance task. When multi-system
malfunctions are present, debrief questions to be answered by flight/ground
crew are provided to aid the technician in fault isolation.

3.4.3.3.1   F-4 WSMAC Microfilm System Indexing Approach

Figures 3.4.3.3 and 3.4.3.3-1 are extracts from the excellent multi-indexing
system developed for WSMAC which, when combined with the MIRACODE
retrieval system,provides the technician an easily accessible, consolidated
and complete source of technical data and maintenance action directives.

SYS 070 0 == LC1

GENERAL INFORMATION - SYSTEM INDEX

GENERAL INFORMATION	CODE	LINE CODE (LC)
MICROFILM AND EQUIPMENT INFORMATION	070	
GENERAL	070 000	5
MASTER SYSTEM INDEX	070 001	6
FILM INDEX	070 002	7
EQUIPMENT OPERATION	070 003	
READER PRINTER	070 003 002	10
LINE CODE	070 003 006	14
GENERAL MAINTENANCE INFORMATION		
PUBLICATIONS	071	
PUBLICATIONS REQUIRED BY OPERATING ACTIVITIES	071 000 300	19

070 002 LC 7

GENERAL INFORMATION - FILM INDEX

MAGAZINE NAVAIR NUMBER	TITLE	CLASSI-FICATION	APPLICABILITY F-4B	RF-4B
01-245FD-2-2.1M	MASTER TROUBLE ANALYSIS	U	X	X
01-245FD-2-2.3M	SYSTEMS INTEGRATION	C	X	X
01-245FD-2-3M	GENERAL INFORMATION	U	X	X
01-245FD-2-4M	AIRFRAME			
01-245FD (5M)	AUTOMATIC FLIGHT CONTROLS	U	X	X

MAG 2-14 000 LC1

AUTOMATIC FLIGHT CONTROLS - COMPOSITE INDEX

TITLE	SYSTEM INDEX CODE	LINE CODE (LC)
AUTOMATIC FLIGHT CONTROLS		
AUTOMATIC FLIGHT CONTROL SYSTEMS		
FLIGHT CONTROL GROUP AN/ASA-32G	572	99

SYS 572 LC 99

FLIGHT CONTROL GROUP AN/ASA-32G - SYSTEM INDEX

TITLE	CODE	LINE CODE (LC)
FLIGHT CONTROL GROUP AN/ASA-32G	572	
DESCRIPTION AND OPERATION	572 000 3XX	117
MAINTENANCE INFORMATION	572 000 360	
TROUBLE ANALYSIS	(SYS 050) 572 001	

Figure 3.4.3.3   WSMAC F-4 GENERAL INDEXES

SHEET 55

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Note in the two illustrations, the variety of indexes provided. This is the heart of the access system! Each F-4 index page normally has the access code typed on the lower left footing of the page. In the sample indexes shown, the access codes have been re-typed on the top left heading of each index page in order to facilitate showing the top portion of four indexes (with their access codes) on a single page.

In Figure 3.4.3.3, note the GENERAL INFORMATION - SYSTEM INDEX that provides the information (via noun name) necessary to find any subject or other indexes; for instance, if you don't know how to operate the reader-printer, you can depress the code keys indicated in this index under "reader-printer" and obtain the information. Note the FILM INDEX and its code. This index covers the various film magazine "categories" such as MASTER TROUBLE ANALYSIS, AIRFRAME, FUEL SYSTEM, etc. If you wanted information on the Automatic Flight Controls system you would select and insert film magazine ---2 - 14 in the reader-printer and depress Line Code (LC) 1 for page 1 and the COMPOSITE INDEX shown would be displayed.

Note that the first two digits of the binary "access" code for the Automatic Flight Control System is 57 which is the official Work Unit Code (WUC) number per MIL-M-38769 and AFM 300-4 (References 11 and 12). for integrated (automatic) flight control systems. Thus, a technician with a fuel system problem would access with digits 46, or 13 if he has a landing gear problem. If you wanted information on the Flight Control Group, AN/ASA-32G, you'd depress 572 (LC) 99 to obtain the detailed SYSTEMS INDEX shown that covers this "group".

Figure 3.4.3.3-1 shows the index route you'd probably follow if you were trying to rectify a fault in the AN/ASA-32G group. Using the AN/ASA-32G SYSTEMS INDEX discussed in the previous paragraph, you'd first locate the Trouble Analysis code. This would direct you to the MASTER TROUBLE

SYS 050, 000 LC 1

MASTER TROUBLE ANALYSIS - COMPOSITE INDEX

TITLE	SYSTEM INDEX CODE	LINE CODE (LC)
MASTER SYMPTOM INDEX	001	3
ENGINE MAINTENANCE REQUIREMENTS INDEX	003	5
GENERAL TROUBLE ANALYSIS INFORMATION	004	7

SYS 050, 001 LC 3

SYSTEMS INTEGRATION - MASTER SYMPTOM INDEX

AIRFRAME	111
CANOPY SYSTEM	163
AUTOMATIC FLIGHT CONTROLS	41
FLIGHT CONTROL GROUP AN/ASA-32K	573	95

SYS 050, 573 LC 95

FLIGHT CONTROL GROUP AN/ASA-32K - SYMPTOM INDEX

SYMPTOM	SYSTEM	MAL-FUNC-TION CODE	LINE CODE	AIRCREW DEBRIEF REQUIRED
AFSC MODE				
AFSC SWITCH WILL NOT ENGAGE	050	218	396	P
AFSC SWITCH DISENGAGES ERRON-EOUSLY IN FLIGHT	050	325	503	P

SYS 050 218 LC 396

MALFUNCTION ANALYSIS   CODE

AFSC SWITCH WILL NOT ENGAGE   218

Was AI OFF flag in view?

    YES   Troubleshoot per (Aircrew debrief required)   058
    NO   Did AI function correctly in pitch in STBY position?

        NO   Troubleshoot per (Aircrew debrief required)   (SYS 734) 960
        YES   Is 70 vdc present at 65 - P305B/50?

            NO   Does continuity exist from 65-P305B/50 to
            71-P-311A/10?

Figure 3.4.3.3-1   WSMAC F-4 TROUBLE ANALYSIS INDEXES

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ANALYSIS - COMPOSITE INDEX that would lead to the other indexes and information shown on Figure 3.4.3.3-1. Note that the last abbreviated page shown is not an index but the beginning of the MALFUNCTION ANALYSIS portion that uses logic tree trouble analysis diagrams. These lead to the fault and/or reference the technician to other troubleshooting or maintenance procedures (repair, replace, checkout and etc.).

3.4.3.3.2   F-4 WSMAC Microfilm System Evaluation

The WSMAC re-arrangement and re-indexing of the conventional military technical manual information for use in the MIRACODE microfilm system is a major maintenance information presentation breakthrough!

WSMAC has reduced unnecessary "wordy" information, and the difficult cross-referencing between bulky printed publications problem. The superior logic tree fault isolation methods and the excellent integrated multi-indexing system (with the standardized work unit "system codes" as the first two digits of the binary access code) that permit immediate access to a complete and well organized Organizational/Intermediate maintenance level data bank are also outstanding features of the WSMAC microfilm system.

Other advantages apart from the microfilm advantages (file integrity, retrieval time, space savings and updating ease) are as follows:

a. Minimizes on-site personnel human factor problems such as the reluctance to read through pages of instructions relevant to the repair of an item.

b. Provides the following savings:

(1) Time - The retrieval and printout of almost any maintenance action is available to the technician within two minutes. The AGE, tool and parts needed for the task are also identified.

(2) <u>Space</u> - The "technical library" is now microfilm magazines.
The reference technical manual tables and research areas are
eliminated and the retrieval station becomes the focal point of
all maintenance actions.

(3) <u>People</u> - The training of personnel is enhanced by using WSMAC
data. The accuracy of the maintenance action means less
repetitive maintenance. Publication distribution time and
shipping costs are saved.

3.4.3.4   Army FLATTOP Microfilm System

Project FLATTOP is an Army program designed to provide depot level
maintenance for combat helicopters in Vietnam (Reference 13). The Army
is using an ex-Navy seaplane tender with fore and aft landing pads. The
helicopters fly in, or are hoisted aboard, and are taken below on an elevator
for the depot maintenance work by the Army's First Transportation Corp.
Battalion (Seaborne - Aircraft Maintenance Depot).

Since this mobile depot level maintenance concept involved all Army rotary -
wing aircraft except the Sikorsky CH-54A Flying Cranes, a large technical
data library covering millions of images (pages) were microfilmed under
the direction of the Army Missile Command, Redstone Arsenal, Alabama.
The technical manual/document library is on 16mm film and Brown Engineering
16mm reader-printers similar to that shown in Figure 3.4.3.4 are employed.
These feature large 18 x 24-inch viewing screens. MIRACODE retrieval
control units, and Itek reproducers (or printers). Itek reader-printers are
used for displaying and printing 35mm aperture card data. Engineering
drawings and other larger formatted data are reproduced on 35mm film and
placed in aperture cards. The reader's large 18 x 24-inch viewing screen
almost doubles the image area (in comparison to conventional 16mm readers).
This large screen greatly enhances the legibility of oversize documents such as

18" X 24" SCREEN

MIRACODE*
RETRIEVAL
CONTROL
UNIT

PRINTER
(ITEK)

MICROFILM
STORAGE
FILES

BROWN ENGINEERING   16MM READER-PRINTER

ITEK 16-35MM ROLL FILM/
MICROFICHE READER-
PRINTER (ENG. DRAWINGS)

RECORDAK LODESTAR
READER-PRINTER
(MANUALS -
DOCUMENTS)

MIRACODE*
OR IMAGE
CONTROL
RETRIEVAL
UNIT

MICROFILM
STORAGE FILES

* KODAK TRADEMARK

DUAL READER-PRINTER SYSTEM

Figure 3.4.3.4   ROLL FILM READER-PRINTER SYSTEMS
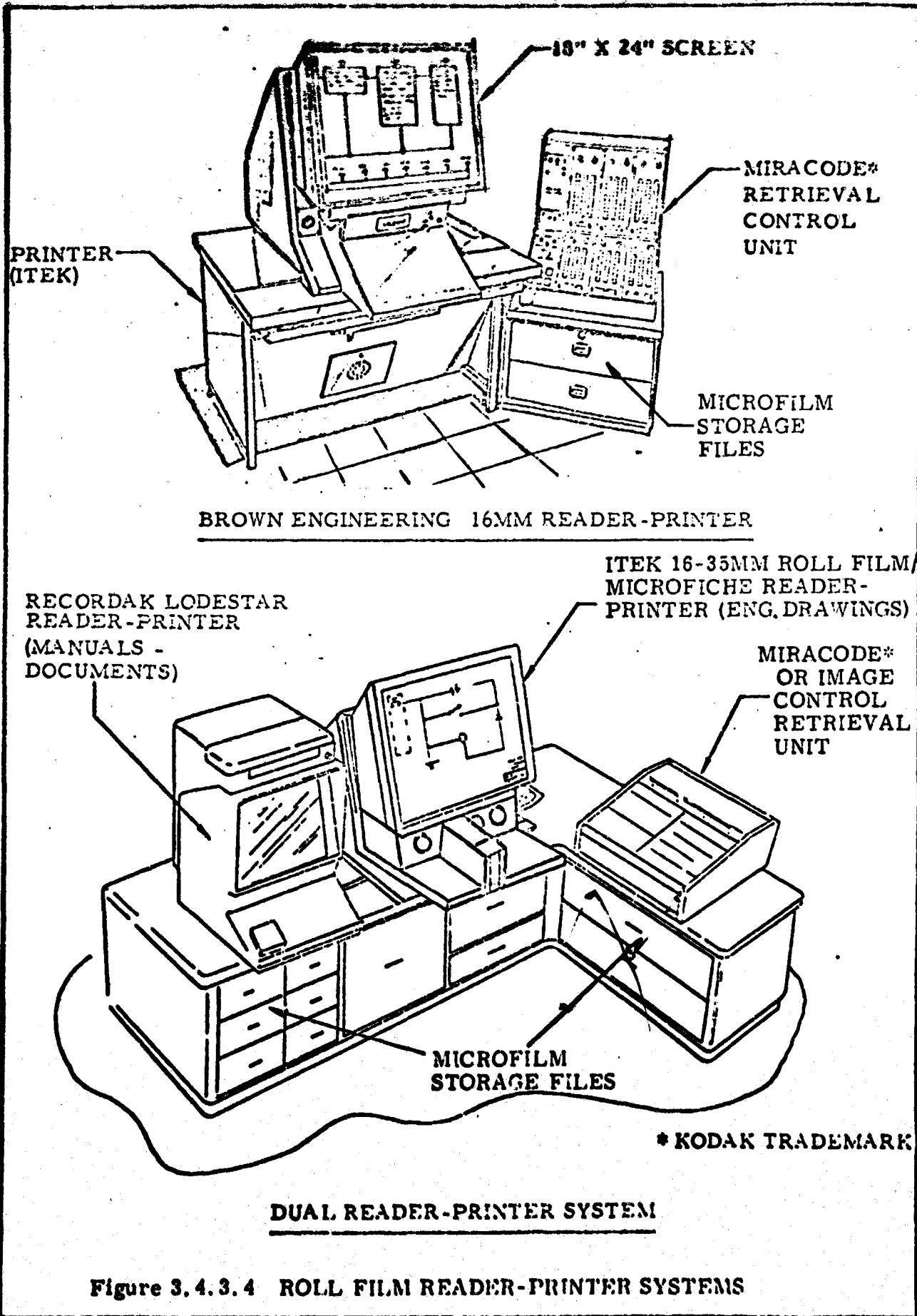
C-size drawings (aperture card) which this equipment also handles. The printer

utilizes the latest Itek reproducer which is capable of delivering an 18 x 24-inch

hard copy within 10 seconds. The printing cycle is fully automatic and the

prints are exposed, cut, processed, and delivered squeegee-dry.

Technicians from 32 different machine shops located on five different decks

have immediate access to the maintenance information required for depot

overhaul of helicopters, engines, rotors, transmissions and hundreds of other

items. This microfilm system saved from 95 to 98% of the space usually

consumed by technical manual/document/dra' 'ng files on board a ship.

The MIRACODE retrieval system is the heart of this large 16mm film technical

manual library. Various types of maintenance information may be quickly

retrieved (via a multi-indexing access system similar to the WSMAC approach),

even though the part number, drawing number and/or technical manual number

is not known by the technician.

The Itek equipment used in this project is off-the-shelf equipment. The

Itek Corporation is a pioneer in the design of all kinds of microfilm equipment

including a new reader-printer (Mo‹ . 18-24F) with the large 18 x 24-inch

screen, that will handle microfilm jackets up to 5 x 8 inches, aperture cards,

16mm and 35 roll film and microfiche up to 5 x 8-inches. Selective portions

of any item being viewed may be printed by means of a unique mask system.

3.4.3.5   Army Engineering Data System (EDS)

The Army Missile Command, that developed the Flattop System, has also

developed two Engineering Data Systems (EDS) designated EDS-0009 and 0016

that employ the MIRACODE System and the wide screen reader-printer shown

on Figure 3.4.3.4. These systems are designed for the small, medium and

large engineering data users.

For a small scale data base, a manual microfilm input camera and low-cost

35mm to 16mm (aperture card to roll film) light box converter are employed to

establish the file. For a medium size data base, a 35mm to 16mm converter and semi-automatic camera is used. For the large and complex data base, an optical scanner to microfilm device is used to establish the file. In all cases, the data is recorded on 100 foot rolls of 16mm film and the MIRACODE equipment and wide screen reader-printers shown on Figure 3.4.3.4 are used for retrieval.

The Army Missile Command has also designed an improved retrieval control unit for use in MIRACODE information retrieval stations. This militarized unit shown on Figure 3.4.3.5, is produced by Western Reserve Electronics of Cleveland, Ohio. This unit meets the environmental requirements of military specifications for electronic equipment, has built-in fault isolation capabilities and other improved reliability and maintainability design features.

3.4.4 3-M Company Microfilm Applications

3.4.4.1 Airline Applications

The 3-M Company's Microfilm Systems Division has been one of the active participants in 16mm microfilm technical manual applications. Section 5 describes a number of airline technical manual microfilm applications and Figure 5.3.2 represents a 3-M 400C 16mm reader-printer in operation by American Airlines personnel. More 3-M 16mm microfilm readers and reader-printers are being used by the airlines than any other microfilm equipment.

3.4.4.2 Navy Applications

Hundreds of 3-M reader-printers are being used by the Navy in technical manual microfilm programs. Two of these roll film programs, the NARF-JAX and RAPIDS technical manual microfilm systems, that are using 3-M equipment, are described in the following paragraphs. These two programs are part of the Navy MIARS Program that is discussed in paragraph 6.3.6. The MIARS Program is a group of programs designed to transform Navy printed technical manuals into microforms.

THE *BOEING* COMPANY

- Army Militarized Electronic Control Unit For Retrieval Devices Using MIRACODE (Kodak) Concept.

- Contractor - Western Reserve Electronics
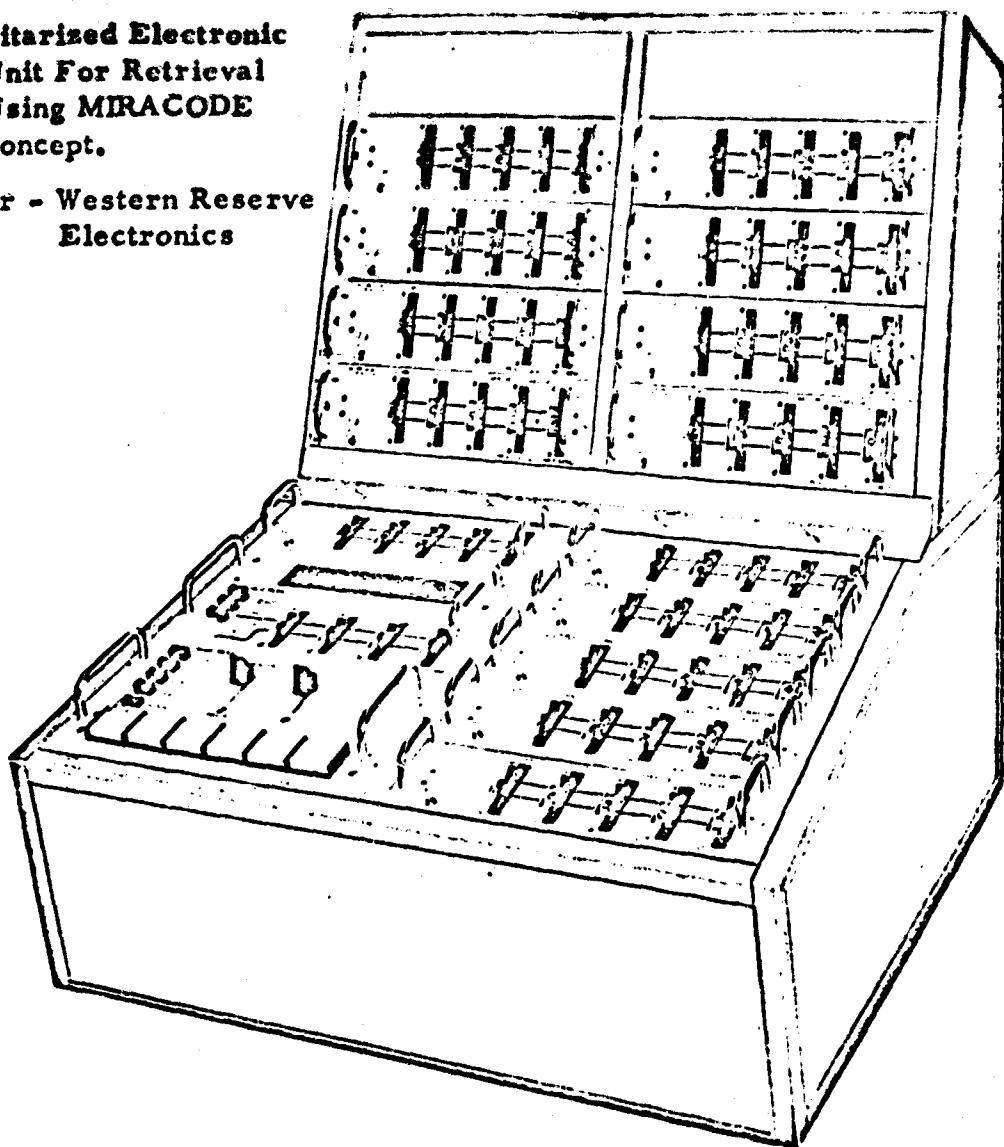
FEATURES

- MEETS ENVIRONMENTAL REQUIREMENTS OF MILITARY SPECIFICATIONS FOR ELECTRONIC EQUIPMENT

- SIMPLIFIED OPERATOR CONTROL PANEL

- BUILT-IN FAULT ISOLATION

- AUTOMATED RETRIEVAL OF ADRESS FILMS

- PLUG-IN FUNCTION MODULES AND REPAIR PARTS

- INTEGRATED CIRCUIT (3RD GENERATION) DESIGN

- WEIGHS 120 POUNDS

FIGURE 3.4.3.5 MILITARIZED RETRIEVAL CONTROL UNIT (ARMY)

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BOEING COMPANY

3.4.4.2.1 NARF/JAX Technical Manual Microfilm Program

The Naval Air Repair Facility (NARF)/Jacksonville (JAX) Technical Manual Microfilm Program involves microfilming the A-4, A-5 and A-7 aircraft technical manuals. A data manager has been assigned for each aircraft type. The data manager is the key to the system and is responsible for the master file that assures that all data filmed is correct and up-to-date. This pilot system, based on commercial airline 16mm microfilm experience (see Section 5), has been in operation for approximately two years and uses 3-M 400C reader-printers. The dual (paper and microfilmed manual) test system has recently been phased out and the -01 and -02 series technical manual operational microfilm program implemented. One of the Navy's technical manual microfilm advocates, Cdr. G. E. Bethune, recently stated the following regarding this program:

> "File integrity is one of the most important advantages of the NARF/JAX test results. If this microfilm system costs the Navy more than the paper system it would be well worth it considering the file integrity advantage alone! NARF/ Jacksonville would like to remove all paper technical manuals as soon as possible and use microfilm only" (Reference 2).

The 3-M 400C reader-printer employs an "odometer" for locating the correct image on the non-coded 16mm roll film and also a "line code" attachment on each side of the viewing screen. The NARF/JAX program is using rotary microfilm cameras that are capable of copying 4000 technical manual pages per hour and automatically line coding each page. Present plans call for updating the aircraft technical manual microfilm files every 30 days. The Navy also plans to implement the NARF/JAX microfilm system at other Naval Air Repair Facilities.

3.4.4.2.2   Grumman RAPIDS Technical Manual
                        Microfilm Program

Another Navy technical manual microfilm program that is using modified
3-M equipment is RAPIDS which is an acronym for Rapids Automated
Problem Identification Data System. This microfilm system was developed
by Grumman for their A-6 aircraft. It is similar to WSMAC (paragraph
3.4.3.3) in that it uses a 16mm film technical information bank for
accomplishing unscheduled maintenance. It differs from WSMAC in that
RAPIDS is designed for organizational level use only. Also, it is not a
complete maintenance information microfilm system since RAPIDS
supplements the printed A-6A aircraft technical manual system. Each film
frame is coded ("Image Count" technique is now used) for rapid retrieval
via the malfunction approach shown in Figure 3.4.4.2.2. RAPIDS, as shown
in Figure 3.4.4.2.2, is essentially a method of presenting maintenance
information in a detailed logic-flow, step-by-step, checklist form.
RAPIDS tells <u>what</u> to do and <u>how</u> to do it!

Grumman states that troubleshooting data is primarily based on fault
symptoms experienced during design, development and operational testing
of the weapon system. Most operational, mechanical and avionics mal-
functions (75% according to Grumman statistics) will occur prior to
delivery of the weapon system to the user. Therefore, RAPIDS covers most
of the expected malfunctions, with their associated symptoms, and necessary
corrective maintenance procedures that have been used successfully by
Grumman maintenance technicians (Reference 15).

RAPIDS initially used MIRACODE retrieval equipment. This commercial
equipment was not designed for a military environment and encountered the
following problems in early tests at the Naval Air Station, Whidbey Island,
Washington.

    a. Fluid spillage that caused component failure.

    b. Environmental problems due to dust (on film and optics), heat and
       humidity.

THE BOEING COMPANY

USE FOR TYPEWRITTEN MATERIAL ONLY

Illustration Source:

Grumman Corporation
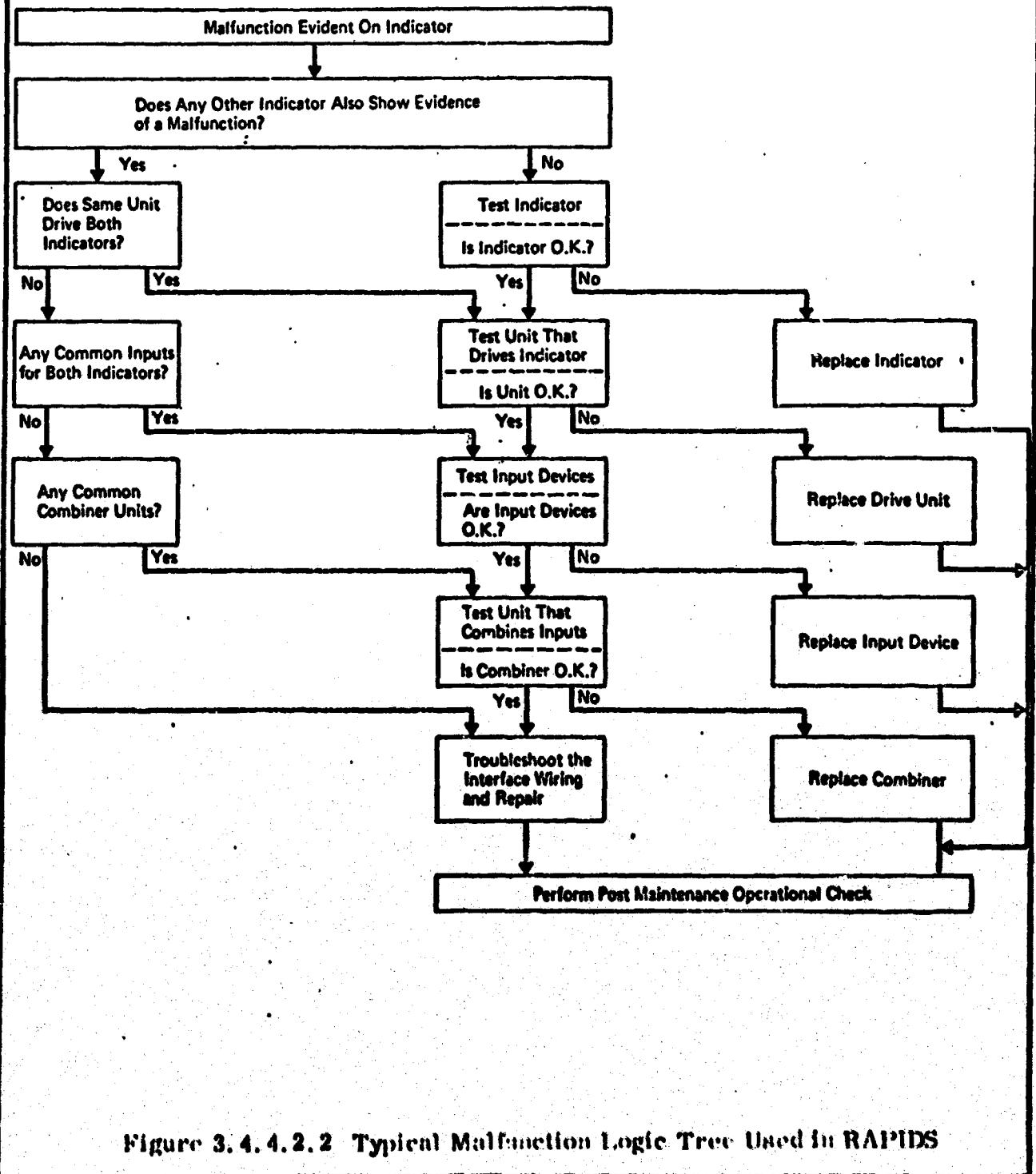
Figure 3.4.4.2.2 Typical Malfunction Logic Tree Used in RAPIDS

c. Connector mating problems.

There were also software problems. However, the software procedures
initially used on Whidbey Island were generated for Grumman's in-house
production/flight test use and were subseqnehtly re-tailored to military
requirements. Also, the non-militarized reader-printer and retrieval control
equipment was employed in a difficult environment. Militarized retrieval
control devices (paragraph 3.4.3.5) are now available for MIRACODE
applicatio s and "dry" development processes are also available in printers
suitable for military applications.

As a result of their equipment problems, Grumman designed and developed
the new RAPIDS retrieval station (Model GC-1A), shown in Figure 3.4.4.2.2-1,
that is suitable for Navy shipboard environment. The semi-dry printer in the
new retrieval station is basically a 3-M 400C reader-printer modified for
military use, according to a recent article on the RAPIDS system in Aviation
Week and Space Technology (Reference 16). The Model GC-1A is being built
by the Applied Devices Corporation for Grumman. The equipment is housed in
a single cabinet and comprises two major assemblies. The upper assembly is
the reader-printer, the lower is the keyboard/electronics control unit. Both
assemblies are mounted on slides for ease of replenishing printing paper and
print activator and for performing inspection and maintenance (Reference 17).

In each 16mm cartridge, a master index lists the individual indexes by the
technical category of the data and the code for each index. Required data
may be located by malfunction, maintenance action, test equipment operating
procedure, operational check, illustrated parts breakdown component and
access items. Access to the technical data bank is accomplished by means
of a series of indexes as shown in Figure 3.4.4.2.2-2. Retrieval of the technical
data is accomplished by a simple coding system. A code number is used for
each page or series of pages. The first two digits identify a system or subsystem,
the third digit identifies a data category within the indicated system such as the

Paper Print Opening
Power Switch
Light Indicator
Viewing Screen
Cartridge
Manual Film Drive
Focus Control
Print Cut Button
Threading Lever
Cutter Control
Low Paper Ind Light
Speed Control Knob
Print Button & Exposure Knob
Mode Selector
Keyboard Readout
Single Image-Fwd/Rev Search, Rewind,
Image Stop Adjustment
Stop Button
Keyboard Code Selector and Clear Buttons
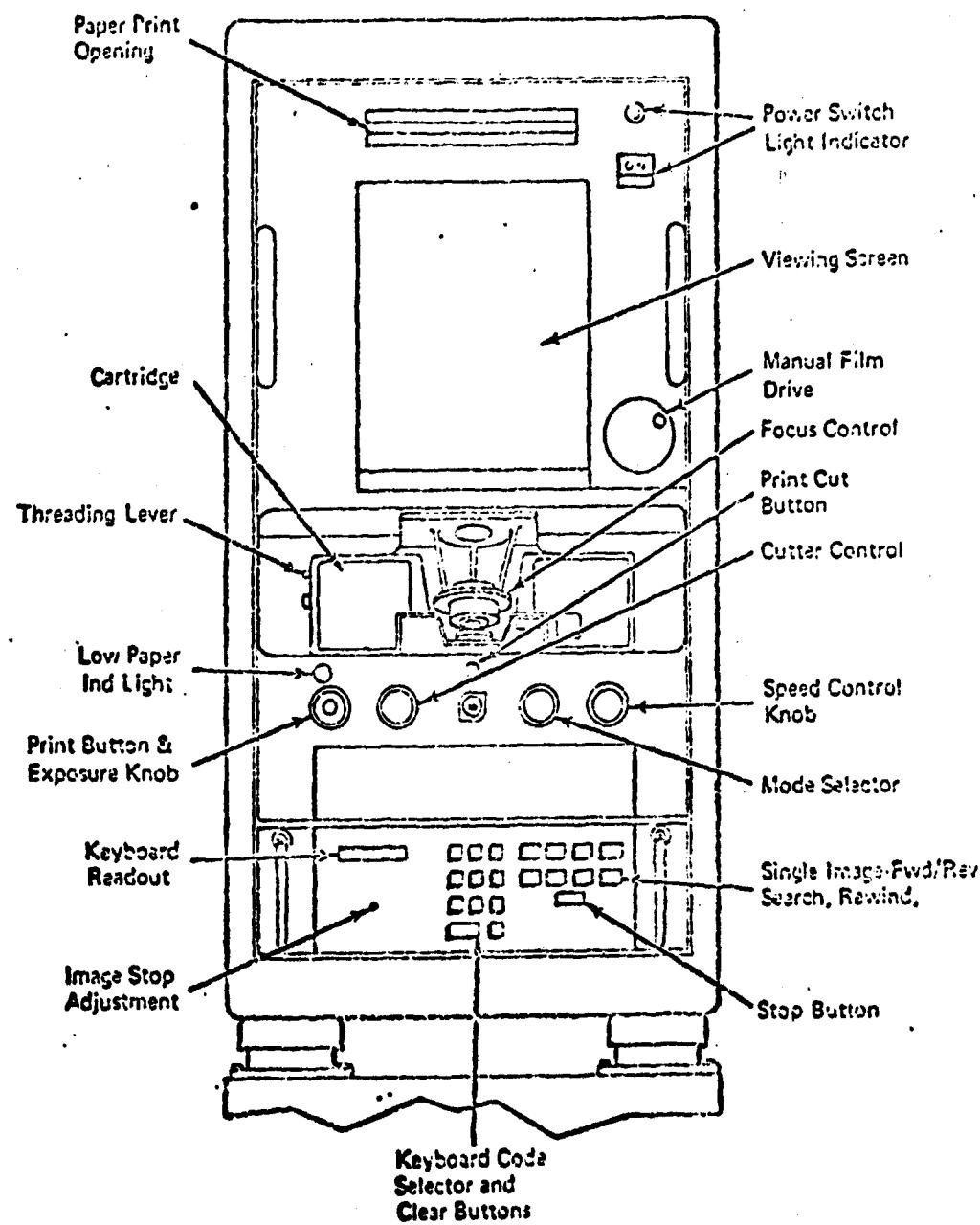
MAIN FEATURES

- Militarized unit
- Minimum logistical requirements
- Three distinct modes of operation
- Fast retrieval of data (10 seconds)
- Fast print (6 seconds)
- Immediately usable copy
- Front loading
- Auto/manual film threading
- Automatic self test
- Accepts all known 16 mm Mil Spec microfilm

Illustration Source:

Grumman Corporation

FIGURE 3.4.4.2.2-1 GRUMMAN RAPIDS SYSTEM READER-PRINTER

Illustration Source:

Grumman Corporation
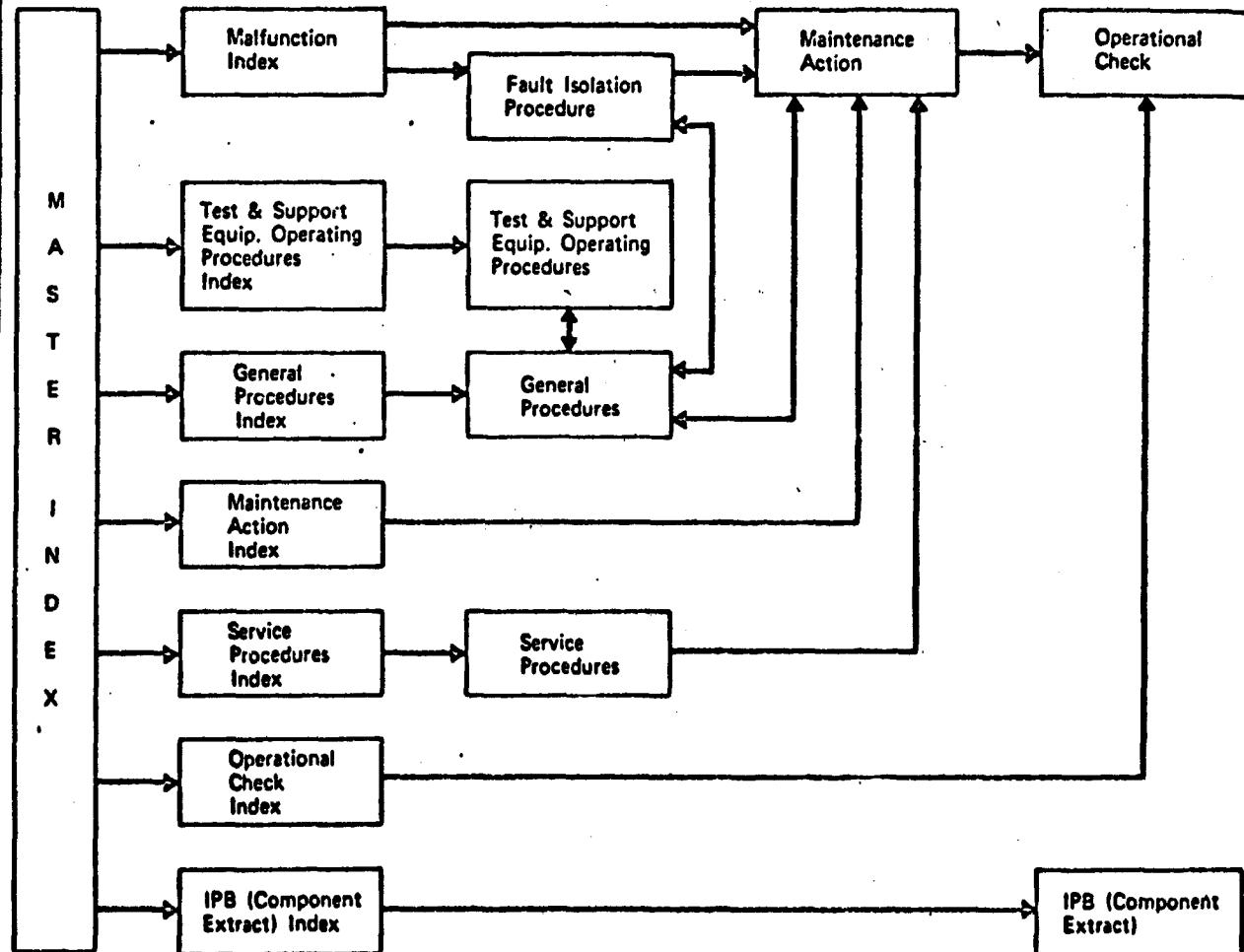
NOTE: All Data Retrieved by Code Number

Figure 3.4.4.2.2-2 RAPIDS Multi-Index Data Access Approach

USE FOR TYPEWRITT .ATERIAL ONLY

following:

- General Information
- Fault Isolation Procedure
- Maintenance Action Procedure
- Service Instruction
- Operational Checkout Procedure
- Support Equipment Operating Procedure
- Illustrated Parts Breakdown

Specific data are called up by push buttons on the front panel keyboard using a six-digit number determined from an appropriate index. Three modes of operation are provided for the data retrieval stations: automatic, semi-automatic and manual.

Grumman initiated its RAPIDS program in mid 1967, in support of A-6A production and flight test operations. Since the introduction of RAPIDS at Grumman, manhours expended for unscheduled maintenance have been reduced significantly, accompanied by a marked reduction in the requirements for skilled technicians, aircraft operational ready rates have improved, spares consumption has decreased and false rejections have improved 60%. (Reference 15).

3.4.4.2.3   Navy F-14A Fighter Microfilm Program

The Grumman RAPIDS system is expected to play an important role in the Navy/Grumman F-14A air superiority fighter program. The Naval Air System Command's F-14A contract states that the aircraft technical manual data shall be provided on microfilm (Reference 63).

3.4.4.3   Other 3-M Military Applications

3-M readers and reader-printers have also been used in Army (paragraph 4.5.3.5.2) and Air Force technical manual test applications. Currently, the Air Force is evaluating at the Warner-Robins Air Materiel Area (WRAMA) a new semi-automated (keyboard access) reader-printer developed by 3-M. The Air Force is also conducting technical manual/engineering data microfilm tests at the Oklahoma City Air Materiel Area (OCAMA) as well as at the WRAMA.

US 4107 1434 REV. 8-68

8.4.5 Command Retrieval Information System (CRIS)

CRIS, an acronym for Command Retrieval Information System, is produced by the AMECOM Division of Litton Industries. This system has not been used in any known technical manual application but is presented since it represents a unique automated microimage storage device that could be used for storing a large technical manual library. Sequential access to stored images is achieved in less than 2 seconds.

The basic unit is a desk-sized console with a 21 x 28-inch display screen, keyboard entry unit, and a film output system. The cartridge (17 by 16 by 6 inches) contains a roll of film called a Kalvar scroll which is 17 inches wide and 200 or 400 feet long. The scroll is divided into 1-3/4 inch wide columns. There are 2590 columns in a 400-foot scroll. Each column, as shown in Figure 3.4.5, is made up of 12 frames, each 1-1/2 by 1-3/4 inches. Eleven frames contain the data images and the bottom twelfth frame contains the retrieval coding.

Each of the eleven image frames is divided into nine subframes. Each of the nine subframes bears a discrete location number. Each of the subframes contains the equivalent of two pages of data at a 30:1 reduction ratio. Each 400-foot scroll can store 511,000 pages of data and any desired frame or subframe can be retrieved in 17 seconds while retrieval time for any frame of subframe on a 200-foot scroll is 10 seconds.

The document pages are initially photographed on silver film (16mm or 35mm). The images on the 16mm or 35mm film are transferred by a controlled step-and-repeat procedure to the Kalvar scroll through use of a Scroll Preparation Unit which is part of the CRIS system. Duplicate scrolls can be prepared by the Scroll-to-Scroll Printer. New information may be added to the scroll through the Scroll Preparation Unit or an Add-a-Frame unit.

SCROLL SIZE	FRAMES	SUB-FRAMES	PAGES	ACCESS
200'	14,080	127,845	—	10 Seconds
400'	28,160	255,690	Up to 1/2 million pages	17 Seconds

FRAME FORMAT

1.75"
.416
.583
1.25"

SCROLL SIZE AND LAYOUT

11 FRAMES
33 SUB-ROWS

17"

CODE GROUP

INDEX AND SEARCH

MANUAL

CARDS   DIRECTORIES   LISTS

AUTOMATIC

PUNCHED CARDS

COMPUTER   MAGNETIC TAPE

MANUAL LOADING

AUTOMATIC SELECTION AND LOADING

CRIS ADDRESS

MANUAL

AUTOMATIC
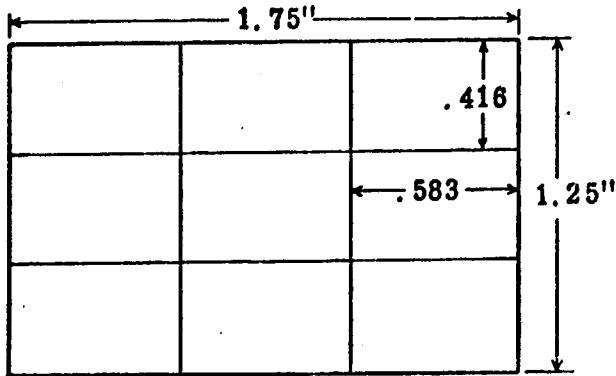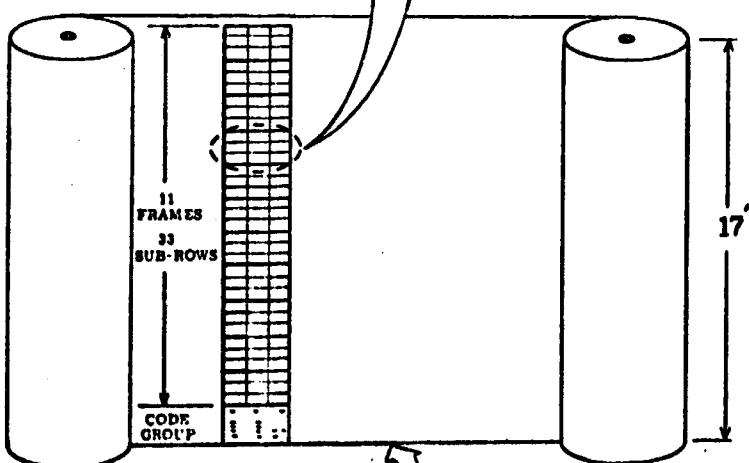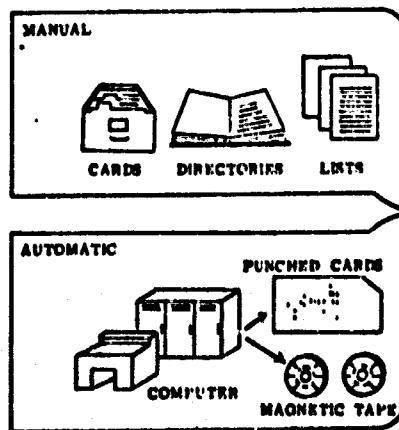
REPRODUCTION AND TRANSMISSION

MANUAL

DIRECT VIEW   FILM OUTPUT   COPY PRINTER   READER PRINTER

OUTPUT

AUTOMATIC   ELECTRONIC PRINTER

OFFSET

ELECTROSTATIC PRINTER
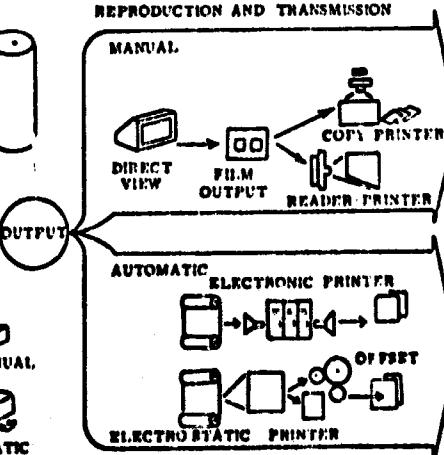
Figure 3.4.5   CRIS SYSTEM

CRIS has a random access capability. The index is maintained independently. It stores the addresses of all documents/data which are entered in index file as received. Documents/data may be added to the scroll without regard to fixed index categories or file locations.

An operator obtains a seven digit code for the required data from the index and inserts the code into the CRIS keyboard. CRIS features a non-return to zero process which means the scroll positioning operation always begins at the last retrieval point without rewinding to point zero. The scroll travels to the next column address within the cartridge while the cartridge moves to the required frame level. For viewing, a scanning key provides the capability to advance from one subframe to another or to the next frame down in the column.

Reproduction of the image may take place in a number of ways as shown in Figure 3.4.5. A film output module facilitates transfer of the retrieved image to a film card, then to copy printer. The CRIS building block design makes it compatible with various transmission systems and reproduction facilities.

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3.4.6 FileSearch System

3.4.6.1

The FileSearch System developed and produced by the FMA Corporation
of Los Angeles has been employed in many military operations over the
past seven years, but has not been used for maintenance information
data bank system purposes. It is presented since it represents an
automated approach suitable for a large technical manual information
bank system at a fixed facility such as a depot. Also, its indexing
approach, as described in Figure 3.4.6.1, has many functional advantages.

3.4.6.2

FileSearch is a self-contained automated system providing complete
logical and comparison search capabilities. It requires a full complement
of equipment for coding, storage, retrieval and display/printout. Each
frame can accommodate a technical manual page (up to 8 1/2 x 14 inches)
and 56 alphanumeric characters of indexing information. Thirty-two frames
can be recorded per foot of 35 mm film. Stored technical manual pages
can be rapidly retrieved by the retrieval unit which automatically scans
and processes the binary indexing information on the film at 6400 pages
per minute. The retrieved data can be viewed on a screen and/or
reproduced as hardcopy (7 seconds) or 1:1 film copy (0.4 seconds per
frame). Each reel in the retrieval unit can contain up to 30,000 pages.
Retrieval can be accomplished by typing on a teletype keyboard a statement
concerning the technical manual pages to be retrieved or by responding to
an electrical signal generated elsewhere such as from a computer or other
remote teletype terminal input. If remote viewing of the image is desired,
closed circuit high resolution TV display of the image can be provided.
The system is designed to interface with large data processing centers so
that it can operate under the control of a computer, as a computer peripheral
storing the image or graphic data bank, or can feed information from the
index on film to the computer for computer manipulation.

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CAPABILITY	FUNCTIONAL ADVANTAGE
• Accepts any indexing scheme	Indexing is determined by subject matter, not equipment limitations.
• Uses both alphabetic and numeric terms	Indexers can use natural language rather than having to translate words and numbers to their binary equivalent.
• Variable length index terms acceptable	Flexibility in selecting and assigning index terms.
• Open-field indexing	Index terms can be recorded in any order, rather than in a particular sequence or position.
• Accepts any number of index terms	Technical manuals or documents can be indexed to any desirable depth, rather than a depth set by system constraints.

FileSearch Indexing Advantages

← Binary Code
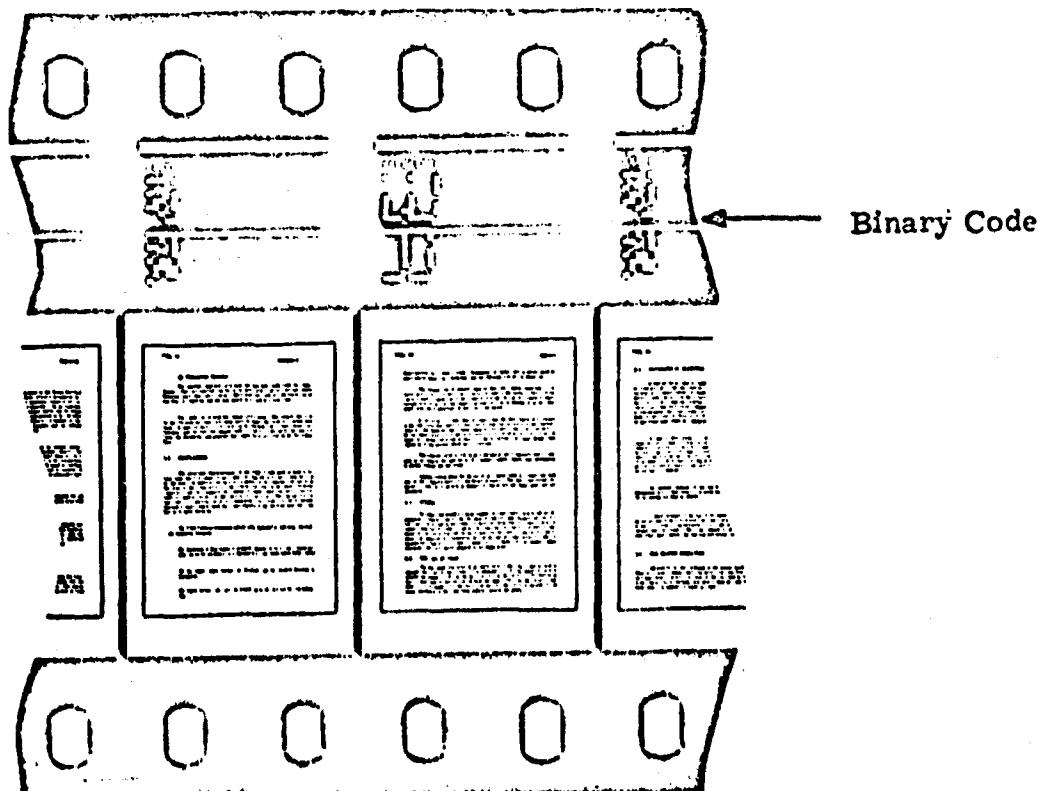
Typical Frames (35mm)

FIGURE 3.4.6.1   FILE SEARCH SYSTEM

3.4.6.3

This system could be used to expand rapidly (search time plus 0.4 seconds per page) specific technical manual 35mm microform systems configured to a specific model or unit. As an indication of the rapidity with which new subject matter reels can be generated, it would take less than an hour to search through a large weapon system technical manual library of 100,000 pages, select 5,000 pages related to a specific subject, and reproduce them on a new reel of film.

U S 4*0: 1494 F F V . 0-/*

3.4.7   Audiscan Corporation Applications

The Audiscan Corporation of Bellevue, Washington produces a light
weight (12 pound) audio-visual (16mm continuous-loop film) device that
is being used by industry and the military services to more effectively
present maintenance information.

3.4.7.1   Air Force Project PIMO Application

The Audiscan film strip system was recently tested by the Air Force
in their technical manual improvement Project 1316, "Presentation of
Information for Maintenance and Operation (PIMO)". This multi-million
dollar test program concentrated on the man-machine interface to improve
the technician's performance capability by providing improved maintenance
information presentation approaches. This involved several format and
presentation concepts. (troubleshooting aids, job-oriented and pocket size
"booklet" type technical manuals and a audio-visual presentation mode).
The audio-visual mode used the job-oriented booklet type maintenance
information and presented this in the Audiscan units. Additional details
on PIMO may be found in Boeing PIMO evaluation document D2-125717-7
(Reference   18   ) and the eight volume Air Force Project PIMO Final
Report (Reference   19   ).

Figure 3.4.7.1 shows the portable Audiscan unit in use, a typical PIMO
maintenance information frame, and some of the features of the Audiscan
unit.

The PIMO audio-visual "system" was comprised of two major parts: the
Audiscan projector/playback and a cartridge which contained the maintenance
information. The cartridge included a 16 mm film strip and a self-looping,
two-track audio tape reel. To operate the device, the cartridge was inserted
into the device and the advance button was depressed. An audio burst
containing one maintenance task would be played. Then, the device would
automatically stop. The machine would give no further instructions until

UPPER
EYEBOLT
JAMNUT

SPRING
SUPPORT
BRACKET

EYEBOLT

CENTERING
SPRING
LEVER

① Engage eyebolt at spring support
bracket. Install washer and upper
eyebolt jamnut.

10301 FRAME 10F9
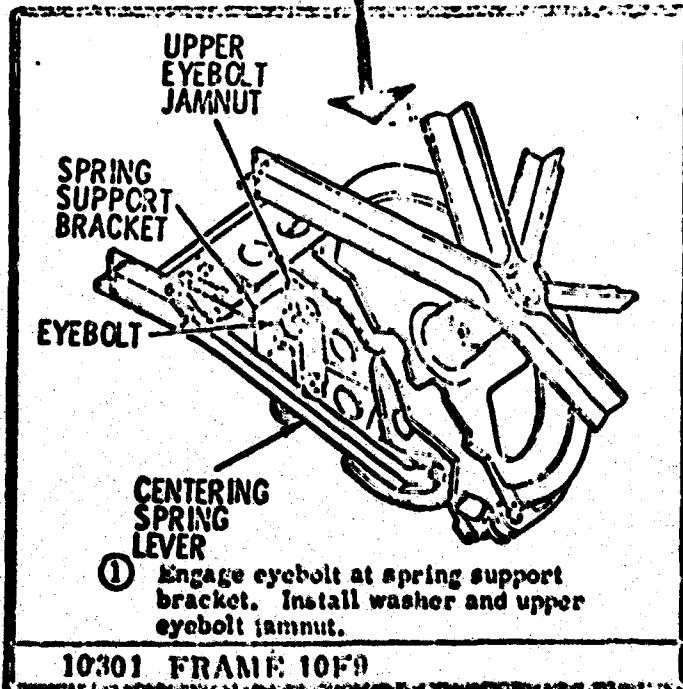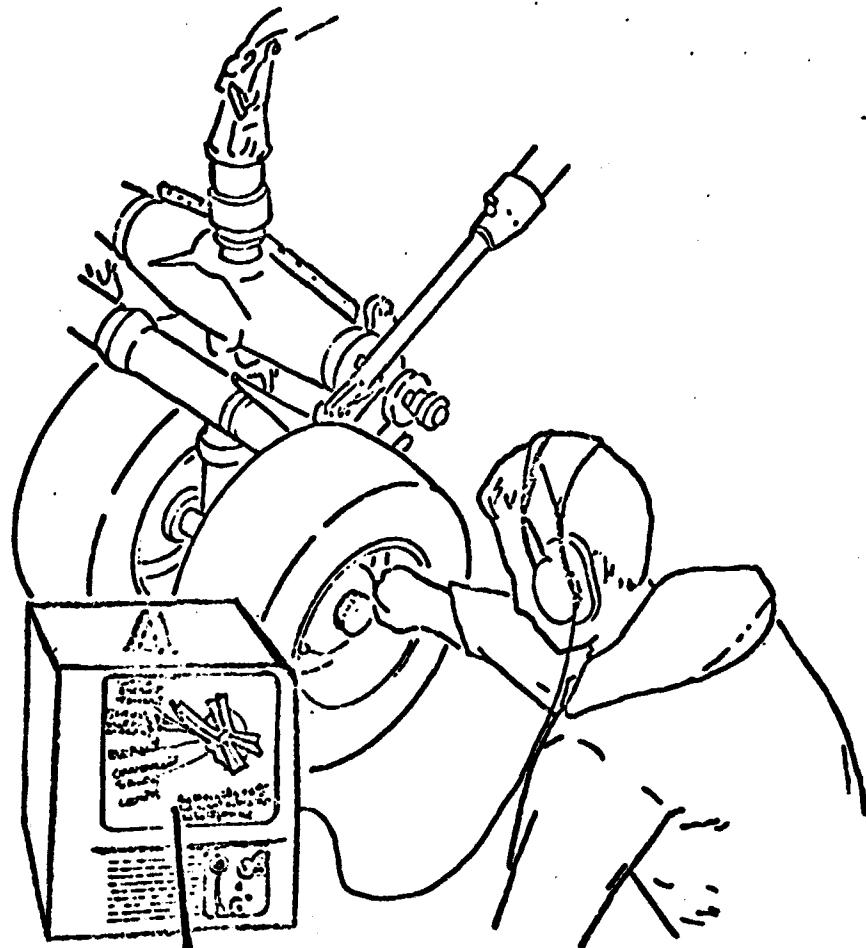
AUDISCAN FEATURES

- Sound/sight in single "snap-in" cartridges (5 x 5 x 1-1/2 inch)

- No rewinding -- instant replay.

- Automatic stop/hold with viewer demand "continue" control.

- Manual hold/picture advance.

- Rapid picture advance programming to 5 frames per second.

- Sealed-in protection for 16mm film and tape (1/4 inch).

- Compact/portable (weighs approx. 12 pounds).

- 225 frames and 25 minutes sound.

Figure 3.4.7.1   AUDISCAN APPLICATION IN PIMO PROGRAM

the advance button was again activated. The visual presentation would advance automatically as dictated by the programmed instructions - - always in synchrony.

For test purposes and in order to reduce search and access time, only one activity was included in a cartridge. The PIMO Audiscan devices were in continuous operation for approximately three months, during which time no equipment failure occurred (Reference 19).

The PIMO field test results indicated that the job guide concept booklet (visual) and audio-visual (Audiscan) modes provide an extremely effective means of improving maintenance while reducing support costs. There were indications of faster learning with the audio-visual Audiscan mode.

Lastly, there were indications that the audio-visual presentation mode, using the same job guide format, can further facilitate training. This may be an effective method to train technicians for activities that occur with such a high frequency that development of job guide data would not be cost effective. The high frequency would assure sufficient retention from one occurrence to the next (Reference 19).

3.4.7.2   Other Audiscan Applications

Audiscan equipment is being used in U.S. Army Project COBET (Common Basic Electronics Training). The course was designed around the systems approach concept to training, with a minimum of theory and a maximum exposure to practical training. The electronic equipments used by the Army were categorized according to the basic electrical components of each and then set up into common groups for maintenance training.

Audiscan audio-visual projectors are being used in a growing number of commercial maintenance information presentation programs. Ryder Systems, a commercial truck rental firm, has had a series of 25 films produced in the

Audiscan cartridge, which are used for preventive maintenance and

inspection training throughout the United States. Since its inception, this

program has been expanded to technical training schools and other maintenance

areas by Ryder. They currently are using approximately 125 Audiscan

projectors.

The Navy/Marines are testing and using Audiscan film/sound equipment

for presenting supplemental technical manual information relative to

helicopter maintenance. Boeing-Vertol developed sound/film step-by-step

maintenance instructions (remove, repair, replace and checkout), as well

as troubleshooting information , are being used to support complex

helicopter systems (flight control, etc.). Step-by-step textual procedures

are not being placed on the illustrations (on the 16mm roll film) as was

done in the PIMO program. The audio portion, which is synchronized

with the visual (illustration) portion, describes how each maintenance

task is to be done.

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3.4.8   Conductron-Missouri Maintenance Information
         Presentation Devices

The Conductron Company of St. Charles, Missouri has developed several
different maintenance information presentation systems which retrieve images
from coded 16mm microfilm and display them on a rear projection viewing
screen. Figure 3.4.8 shows a Conductron developed automatic maintenance
information retrieval/display unit that can be used with the Conductron
automatic test set illustrated. The first application of these items was
with the Army/McDonnell MAW (Medium Assault Weapon) anti-tank missile
avionics. The display unit provides maintenance-repair instructions when
the item under test fails a specific check.

Conductron has developed similar 16mm maintenance information equipment
called Factfinder and MIRS (Microfilm Information Retrieval System).
These can retrieve any coded image from 100 feet of 16mm microfilm within
10 seconds. The search may be content addressable or by image number,
among images randomly sequenced on the film. The equipment may be
portable, airborne or stationary. Control may be manual or automatic. A
dry-process printer can be provided.

In the search mode of operation,the code columns preceding each image are
electronically scanned and compared with the search criteria specified by
the keyboard settings. The operator may select displays of each image
which satisfies the search conditions, or scan   the entire film with a count
of the satisfactory images displayed on the panel. Other controls provide
rewind, single image forward or reverse, and manual slewing. The keyboard
function can be provided in several ways. One method utilizes thumbwheel
switches for insertion and display of the search criteria. Another method
uses a set of keys to insert the information into logic registers which are
displayed by incandenscent readouts. Combinations of these two methods
are also available. Remote and automatic operations are provided when the
search criteria are inserted electronically from other equipments. Operation
is the same except that manual input is eliminated.

U 3 4402 1454 FFN . A.2N

Conductron-
Missouri
Automatic
Maintenance
Information
Display
Unit

16mm cartridge

Punched Tape
Automatic Test
Set

Army/McDonnell Test Set/Maintenance Information
Display Unit
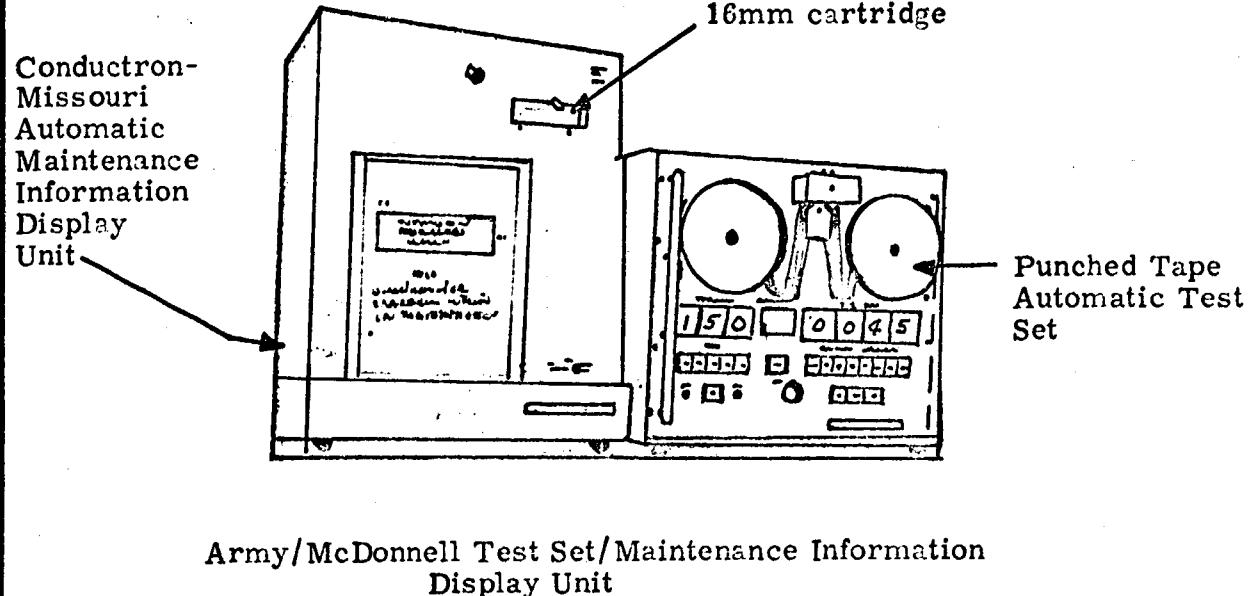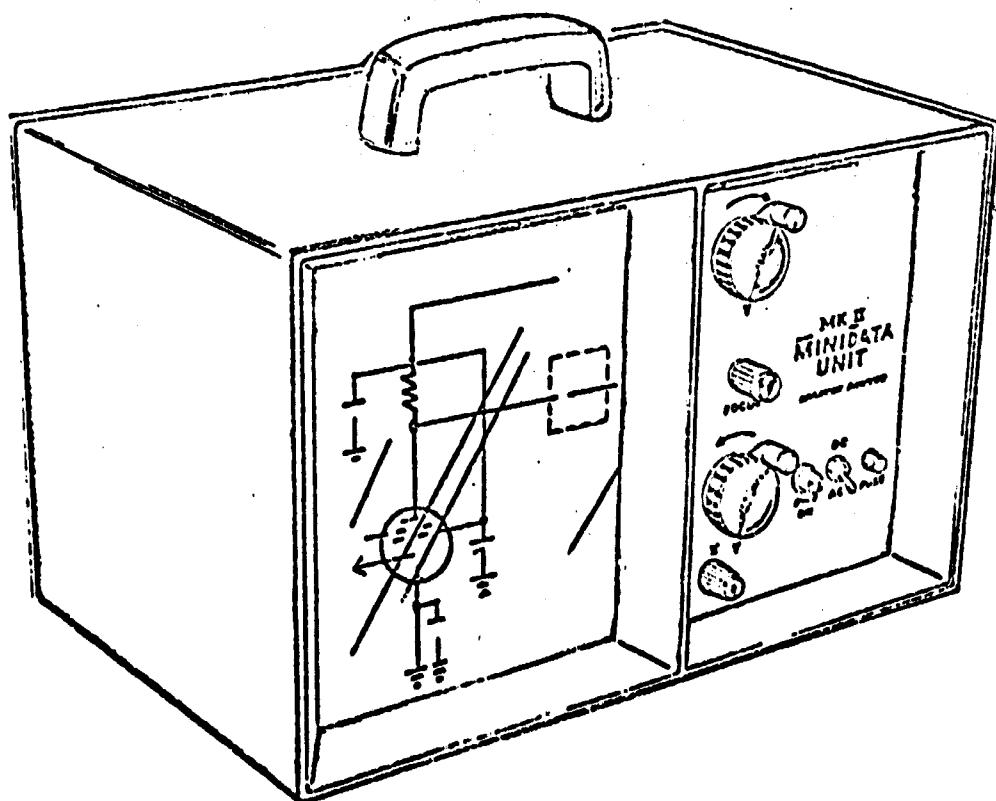
Martin-Marietta Portable MINIDATA Unit

Figure 3.4.8   CONDUCTRON AND MARTIN-MARIETTA DISPLAY UNITS

THE *BOEING* COMPANY

The optional printer can make 8 1/2 x 11-inch hardcopy from any image. The printer uses a dry silver process and can be operated in any position. The control logic provides automatic printing of one or more copies from one or more images in conjunction with the automatic search mode.

An additional option for rider access can be provided by inclusion of a CCTV reading station integral with the projection system, or because of the extremely bright screen presentation, an external CCTV system can be used to look directly at the screen.

The basic transportable microfilm information retrieval unit has a weight of 90 pounds and a volume of 4.3 cubic feet. Weight of the airborne unit is less. The printer option adds 30 pounds. Another suitcase type portable microfilm retrieval unit can, with the appropriate modular power supply plugged-in, operate off of either 50-400 cycle single phase, 28 VDC, or internal battery. The battery module incorporates a built-in battery charger.

3.4.9   Martin-Marietta MINIDATA Unit

The MINIDATA unit shown in Figure 3.4.8 is a portable maintenance information presentation unit developed by the Denver Division of the Martin-Marietta Corporation. This unit is presented since it employed 105mm roll film housed in a cartridge. The prototype used off-the-shelf items and weighed 28 pounds. A 30:1 reduction provides a 35,000 page capacity per 100 feet of film. A hard copy printout capability was not initially incorporated. However, the design permits adaptability to a "piggy back" reader-printer configuration.

The operator uses two basic mechanical controls to obtain the desired frame, One control selects the desired vertical column and the other control selects the desired horizontal row along the entire length of the 100 foot film. The latter control is actually two separate controls; a "fast" handwheel type control for rapid search capability and a "slow" control for pinpointing the row. Any frame on a 100 foot reel can be retrieved within 30 seconds. The 105mm film permits reproduction of large schematics, wiring diagrams,

U.S. APO: 1434 REV. 2-65

MATERIAL ONLY   USE FOR TYPEWRIT

THE **BOEING** COMPANY

drawings, etc., which can be viewed by skewing.

3.4.10   Remington Rand Applications

The Remington Rand Office Systems Division of the Sperry Rand Corporation markets roll film and other microfilm equipment, suitable for any type of maintenance information presentation system, from desk size rotary cameras to processors, readers, reader-printers and storage units. Figure 3.4.10 shows a typical system. The rotary camera shown (Model 88) accommodates 16 or 35mm roll film and its 16" input throat accepts pages 15-inch wide which includes standard 14 x 17-inch diagrams. This camera has a built-in 20-division index coding system called MICRODEX (Registered Rand Trademark). This built-in system automatically codes the images as the pages are photographed. Technical manuals must be taken apart or guillotined. The pages (3 inch stacks accommodated) can be filmed rapidly, as the camera operates 150 paper feet per minute. In addition, you are able to film 2 rolls simultaneously with one passing of the document through the camera. The advantage here is that both the active and security roll are of archival quality and both time and money are saved by not having to perform the duplicating process (security roll). Also, the added cost of a continuous i.rm contact printer is eliminated. The F-88 camera weighs 175 lbs.

Another F-88 camera feature is the built-in automatic exposure control system that assures maximum readability of the microfilm (resolution minimum is 130 lines per mm).

The illustrated reader-printer weighs 68 pounds and the printer 27 pounds. A universal model is also available that accepts 16, 35 and 70 mm rolls, aperture cards, microfiche, film jackets or film sheets up to 8 x 5-inches. Any length of print can be selected from 8 1/2 to 24-inches.

MATERIAL ONLY

USE FOR TYPEWRIT

U S 4405 1434 H I V . 8 - 65

THE *BOEING* COMPANY

16/35MM FLOW-TYPE
CAMERA WITH BUILT-IN
CODING SYSTEM

14 X 17 INCH
DIAGRAMS

TECHNICAL
MANUAL
PAGES

16/35MM
READER-PRINTER

16 MM

35 MM

UNIPRO PROCESSOR

ROLL FILM

16/35MM
MICROFILM READER
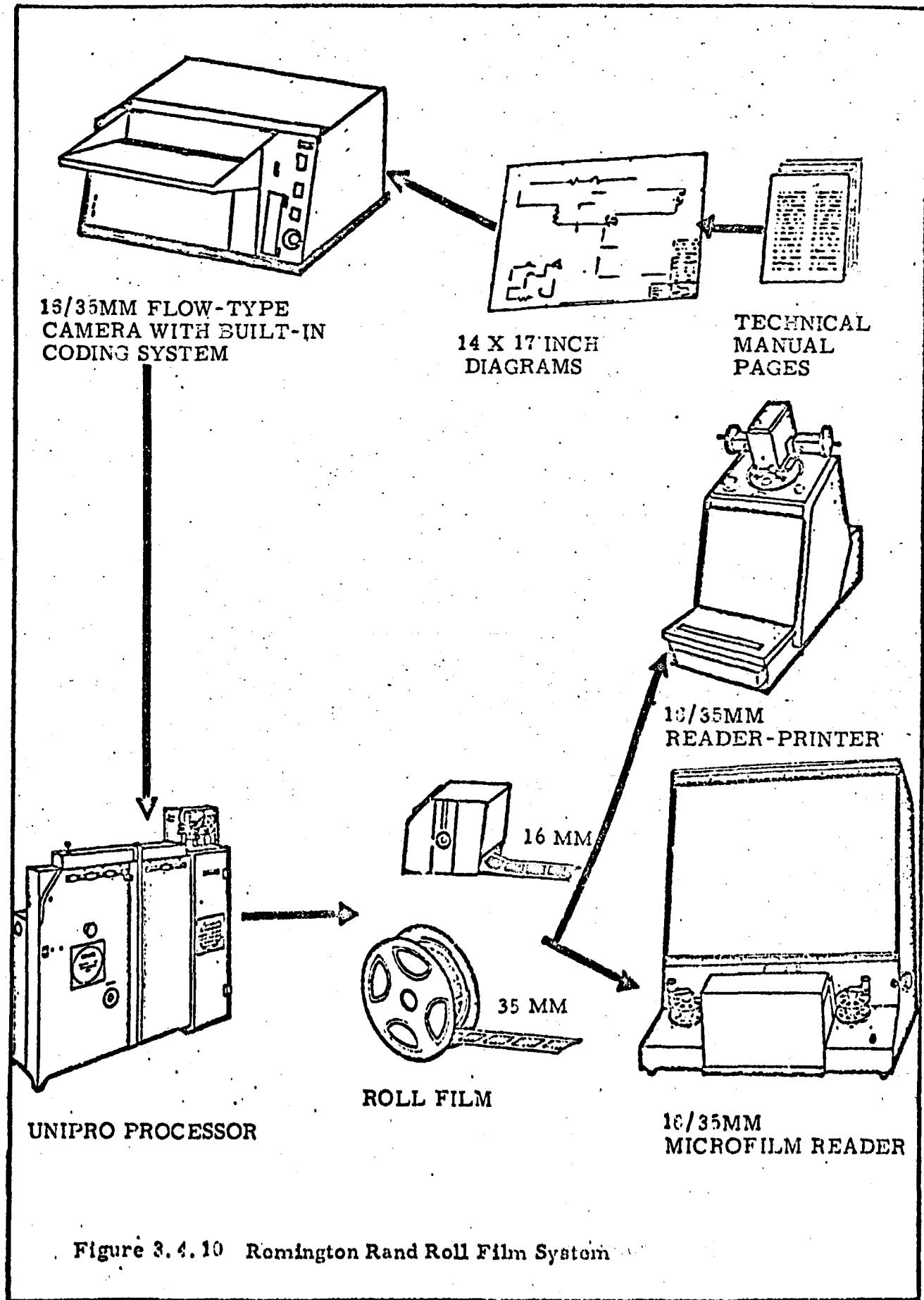
Figure 3.4.10   Remington Rand Roll Film System

THE *BOEING* COMPANY

3.4.11   Information Handling Services (IHS) Reader

A low-cost reader, designed around a dual-track (super 8mm) cartridge that holds 50 feet of 16mm film, has been developed by the Information Handling Services (IHS) Corporation of Englewood, Colorado. Any 8 1/2 x 11-inch page can be located in less than 30 seconds by turning a crank. This compact study reader requires no threading and uses an inexpensive, mailable film cartridge as shown in Figure 3.4.11.

Its unique feature is the super-8mm image with a 37:1 reduction ratio. This permits placing 2500 technical manual pages (images) on each half of a 50-foot strip of 16mm film. Turning the film over gives additional 2500 images for a total of 5000 pages that are stored in a cartridge that is small, light-weight and strong.

A special viewing screen with a Fresnel-like front surface that does not reflect room light made it possible to reduce lamp power to 20 watts. Normal office-level fluorescent lighting still leaves the image sharp and readable.

A two-way manual control shifts the drive automatically, depending on the direction of handwheel movement. This drive also includes a slip clutch to prevent damage to film at the end attachment.

The film-cartridge case is assembled from two identical molded plastic parts that are snapped together after placing the film, spools, and guides in the assembly. The cartridge is 3-inches wide and 6 3/4-inches long and with its 50-feet of microfilm it weighs only 5 ounces.

A battery operated IHS viewer is available for the maintenance technician who works in a remote and confined area.

This unit and its super 8mm image will provide the basis for the lowest cost technical manual system currently available.

USE FOR TYPEWRITTEN MATERIAL ONLY

US 4802 1434 REV. 8-65

THE *BOEING* COMPANY

NON-REFLECTING VIEWING
SCREEN

FRAME LOCATOR CRANK

5000 IMAGE (SUPER-8MM)

MAILABLE CARTRIDGE

(3 x 6 3/4 INCHES)

INFORMATION HANDLING
SERVICES VIEWER (READER)

FOR ROLL FILM   FOR JACKETS   FOR APERATURE CARDS

POCKETSIZE MICROFILM VIEWERS

TAYLOR-MERCHANT

DESK DRAWER

MICROFORM PROJECTOR

Figure 3.4.11   LOW COST MICROFORM VIEWERS

THE **BOEING** COMPANY

3.4.12   Taylor-Merchant Hand Viewers

Thus far, electrically powered manual and automated roll film maintenance
information presentation systems have been discussed. The question is often
asked, what does the technician do when there is a power failure or the
maintenance information presentation system becomes inoperative.

Back-up microfilm presentation systems are available since low cost hand
viewers may be used in an emergency for short duration reading. The Taylor-
Merchant Corporation's Microfilm Division markets a number of different
types of low cost microfilm viewers that permit instant retrieval of the
microfilmed data. These may be used for roll film as well as microfiche,
jackets, unitized, aperture cards and other microforms as shown in
Figure 3.4.11. The handviewer shown has a self-contained light source
powered by two conventional penlite batteries. Two models of this version
are available (12 x or 16 x magnification) and retail for less than $20.00.
These feature a pressure plate that holds the microform in a precise
accurate plane for accurate viewing. The film is protected from scratching
and may be easily moved for scanning. The optics provide for maximum
field of view and minimum peripheral distortion. Other non-battery
models of varying magnifications are available that use any available light
source. Taylor-Merchant also produce low cost desk drawer precision
microfilm projectors, that can be used to project different microforms, on
a sheet of paper, on a wall, or on a screen. For desk top operation, incandes-
cent or ambient light does not interfere with the projected image.

4.0   NON-ROLL FILM MICROFILM SYSTEMS/
                EQUIPMENT

4.1   INTRODUCTION

This section describes non-roll film microformat systems/equipment
and applications relative to the storage and presentation of technical manual
information. The evaluation approach employed in this non-roll film survey
is described in paragraph 3.2. Non-roll film microforms described include
the following:

Unitized

- Film Slides
- Aperture Cards
- Strip Film/Jackets

Opaque Cards

Sheet

- Film Chips/Ultrafiche
- Microfiche

There are various manual and automatic indexing and retrieval approaches
employed in non-roll film systems. In many cases, the individual microfiche,
ultrafiche, film jacket or aperture card is handled as a separate unit. In
automatic retrieval systems digital logic is used. One automatic system
mounts the microfiche in a circular carousel tray and a binary coding strip
on each microfiche is used to provide access for rapid retrieval. Other
automatic systems locate the film chip on a compound table which is
positioned to the desired viewing position by small stepper motors. Other
systems employ 35mm slides in cartridges that are accessed via remote
control (digital) units or synchronized magnetic tapes.

4.1.1   Unitized Microfilm Description

The roll film systems described in Section 3, though excellent for storing
large quantities of data, are difficult to handle when individual frames are
required for frequent reference. Unitizing or breaking the microfilm
up into easily manipulated units lessens this difficulty. At present there
are several methods of unitizing. Film slide systems, that are described

in the first portion of this section, may be considered unitized microfilm.
However, the main unitized methods or concepts are:

Aperture Cards - Individual frames of microfilm are cut out of the
roll ribbon film and mounted in windows cut in cards. In the Filmsort
version these frames are sealed by adhesion around their borders. In
the Microseal variety, the frame is held in a pocket of 1/2 mil Mylar.
These cards, which come in many sizes, may be plain cards or the
coded punched cards as shown in Figure 4.1.1.

Snap Jacks - Here the individual frame of microfilm is slipped into
a ribbed jacket made from cellulose tri-acetate. Then the jacket is
snapped into an aperture cut in a file card. As with aperture cards,
the cards may be of various forms and sizes.

Acetate Jackets - In this version, short strips of microfilm are slipped
into channels formed between sheets of acetate bonded together. Jackets
range in sizes from 3-1/4 x 5 to 5-1/8 x 8 inches and are available
for 16, 35, and 70 mm microfilm. Acetate jackets are officially
recognized as unitized microfilm but in this evaluation, due to their
potential technical manual importance, they are placed in an independent
category called "microfilm jackets" (paragraph 4.5).

Paper Jackets - These are similar to the acetate jackets but are made
of 3-ply paper stock. The film is slid into open channels cut in the
card. Acetate protectors may or may not be used. Paper jackets
range in size from 3 x 5 to 5-1/8 x 8-inches and are cut for 16 and 35 mm
film.

4.1.2   Opaque Card Microform Description

Opaque cards (often called microcards) are a microform but are not
microfilm. Reduced microform images are printed on an opaque surface
and require special opaque-card viewers and readers. Microfilm viewing
equipment can't be used to view or read the opaque images.
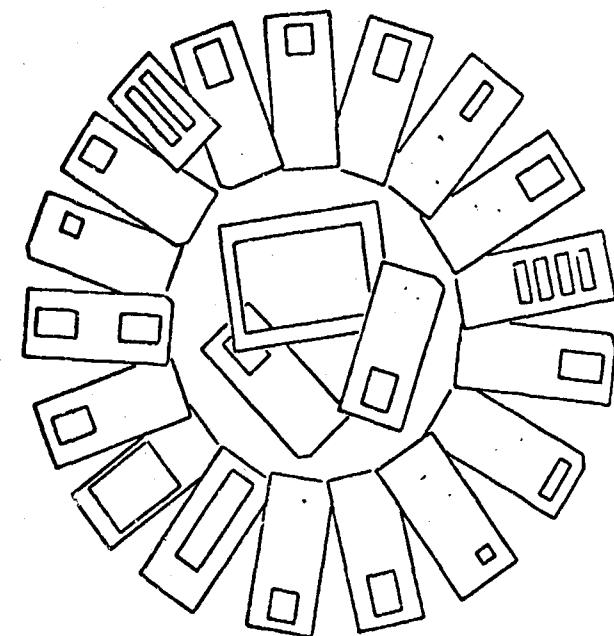
Plain or Coded
Punched Cards

Various Aperture Card Types

Sealed by
Adhesion

Films rt Card

Mylar
Pocket
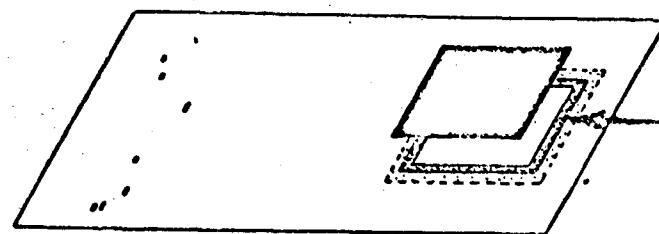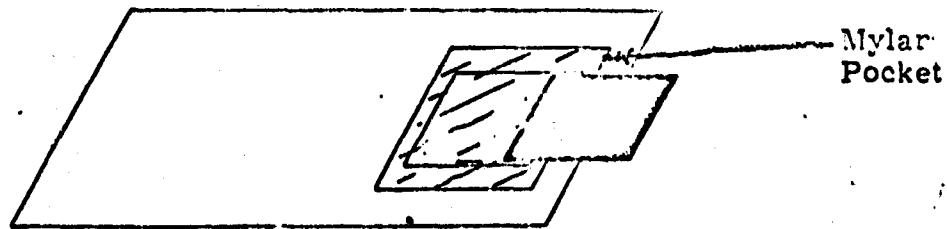
Microseal Card

Illustration Source: (Reference 20)

FIGURE 4.1.1   TYPICAL UNITIZED MICROFILM APPROACHES

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

4.1.3   Non-Unitized/Sheet Microforms

There are other types of microforms that are considered by some as
unitized, though they do not abide strictly by the official definition: "Unitize -
the separation of a roll of microfilm into individual frames and insertion in
a carrier". These are the microfiche, ultrafiche (film chip), and the "paste-
up" variety of micropaper. These types are described in subsequent
paragraphs in this section.

4.2   FILM SLIDE SYSTEMS

4.2.1   Videosonic Audio-Visual System (Slide/Tape)

4.2.1.1   General Description

The Videosonic System which was originally developed by Hughes Aircraft
is now produced by the Weatherford Corporation. This audio-visual device
uses sequentially planned instructions on magnetic tape together with
supporting visual aids (synchronized 35mm slides) to convey maintenance
information to the technician. The slides are viewed on an integral 6 x 8-
inch screen or with an adapter lens on a 4 x 4- foot projection screen.
An ultrasonic (inaudible) "beep" recorded on the instruction tape triggers
each slide automatically. Some models have a manual override "stop"
switch to allow an inexperienced person more time to study any selected
frame. The system is suitable for repetitive routines such as calibration
and assembly in the intermediate and depot level maintenance areas.

Hughes initially designed this audio-visual system for communicating complex
technical information to electronic assembly line workers. When used for
on-the-job instructions, the programmed material resulted in accurate
and concise task definitions that showed and told exactly how each step was
to be performed, in sequence, and at the precise moment it was to be done.
The most complex operations were programmed and tested (Reference 21).

4.2.1.2   Hughes Aircraft Tests and Applications

This concept was initially tested on Hughes' electronics production lines.

The instructions were programmed so that they took into account the
assembler's time and the physical motion required to get parts and tools.
This provided a "packaged" environment for each worker. In addition to
the basic audio-visual equipment, each work station was equipped with
adjustable parts bins, vise-type work holders, and receptacles for all
necessary tools and soldering irons. Tests indicated that when assemblers
were transferred from one job to another, the Videosonic method reduced
retraining time from a month to a week based on a goal of 80% or better
efficiency. In addition, assemblers experienced a 33% increase in individual
productivity and a 60% reduction in rejects. Other results included more
uniform productivity, the freeing of supervisory personnel from instruction
duties, and a 50% reduction in learning time for assemblers. Tests indicated
that an unskilled assembler could achieve at least 80% efficiency on a new
job with a week's training time and three days experience. (Reference 22).

4.2.1.3   Navy Videosonic Applications

The Naval Torpedo Station at Keyport, Washington is responsible for the
preparation of audio-visual maintenance instructions for the Mark 44 and 46
torpedoes. These Navy maintenance instructions are designed for use in
Weatherford Videosonic equipment. These audio-visual instructions are
currently being used at over 50 Navy activities as maintenance aids and
shop training aids. The A-V maintenance instructions are used at the
turnaround maintenance level.

4.2.2   Other Slide Film Approaches

4.2.2.1   Decision System Projectors

Figure 4.2.2.1 shows several typical 2 x 2-inch random access projector
systems built by Decision Systems, Inc. of Paramus, New Jersey. The
top rear-mounted presentation system permits random access to 80 slides.
Thus, operation and maintenance information pertinent to equipment in a
given rack can be retrieved rapidly (1.5 seconds average) and be projected

FIGURE 18-13 (7793)
REV 03

Rack Panel Mounting

15 × 15-Inch Rear
Projection Screen

Remote Control Reader
Assembly
(1.5 Series 1-Axes

Character Position
(2 × 2-Inch)

on a glare-free screen under high ambient light conditions. The jam-proof projector uses "non-spill" carousel type racks that may be easily replaced. Also, the individual slides in each rack may be easily replaced.

The dial-a-slide projectors shown in Figure 4.2.2.1 are typical of those available that can be custom-fitted into consoles, racks or vans and employ either front or rear projection viewing. The digital selection system used in these projectors is designed for interface with other digital equipment. The selection system is engineered for computer control, and no analog devices or "servos" are required. The use of contact closures for slide selection and other provisions provides full electrical isolation. A numerical indicator on the control unit tells the operator which slide is being projected, thus permitting instantaneous coordination with supplemented oral or visual printed maintenance instructions.

4.2.2.2   Ken Cook Audio-Visual Systems

The Ken Cook Company of Milwaukee has developed a number of audio-visual systems that employ 2 x 2-inch slides. These sound-slide systems, that have been successfully used for presenting maintenance information, are built around the Cook Mark VII S/R equipment which is also used as a student-paced teaching machine. This equipment permits projecting the visual image directly on a wall screen, or the image may be projected on an attached rear projection screen in console units, as shown in Figure 4.2.2.2. The top illustration shows this equipment employed in a shop workbench environment. The equipment is shock mounted in order to absorb the pounding and vibration that is characteristic of this environment. A mobile console is also available, as shown in Figure 4.2.2.2. These units use 2 x 2-inch slides (black and white or colored) in easily removed trays, and magnetic tape cartridges that contain the programmed step-by-step maintenance instructions that are synchronized with the slides. Each unit has its own amplifier and speaker. Jacks are provided for earphone usage. These units have been employed in commercial integrated training, production line and maintenance information support programs. The sound-slide

INDIVIDUAL CONSOLE UNITS EMPLOYED IN A SHOP ENVIRONMENT

Console Built Into Stand With Locking Wheels
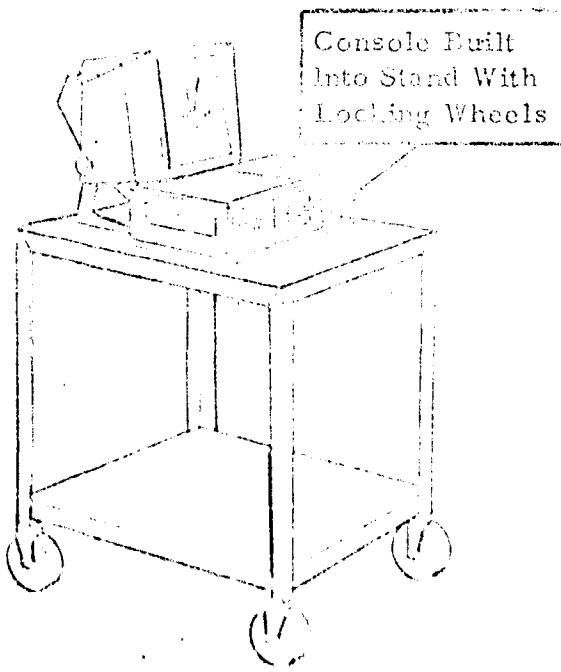
TYPICAL MOBILE UNIT

(Programmed troubleshooting and step-by-step maintenance procedures available anywhere)

MARK VII UNIT IN USE

(Each sound-colored slide program provides 1 hour of maintenance instructions)

FIGURE 4.2.2.2   KEN COOK AUTOMATED AUDIO-VISION EQUIPMENT

procedures in a military program could be validated in the in-house training program and on the production line before employment in the field.

4.2.2.3   Boeing Programmed Instruction Applications

Boeing-Vertol has developed programmed maintenance instructions (PMI) for use in the Ken Cook automated sound-slide equipment. This PMI program, started in 1967, covers helicopter maintenance information and has been tested in Boeing's Learning Laboratory under controlled conditions. One test, a training course application, resulted in a 35% increase in student retention and a 19% reduction in total training time. The Army also has conducted a controlled evaluation program at Fort Eustis that has proved the effectiveness of the Boeing developed sound-slide programmed maintenance instructions. The Army evaluation program used two controlled groups (100 maintenance technicians in each). The first group used the programmed instructions prepared by Boeing and the second group of 100 technicians were taught via conventional classroom methods.

4.3   APERTURE CARD AND OTHER CARD SYSTEMS

4.3.1   Aperture Cards

Aperture cards are punched paper base cards with an opening specifically prepared for the mounting of a frame or frames of microfilm. These have long been the standard for handling engineering data largely because of Department of Defense endorsement and resultant contractual requirements. Since engineering data is part of many maintenance information packages, aperture cards are briefly discussed in this document.

4.3.1.1   Concorde Aircraft Aperture Card System

Aperture cards or 7 x 3 inch data processing (punched) cards with a window that contains an individual 35mm film frame are being used in the Anglo-French Concorde aircraft microfilm engineering drawing program. This system permits a rapid daily exchange of engineering drawing/data between France and England.

The British Aircraft Corporation (BAC) and Sud Aviation are making prototypes of the free world's first supersonic airliner. The microfilm system they use is a development of the 3M Company. In this operation, each completed drawing is photographed several times. The 35mm film is processed and each frame mounted in an aperture card by a semiautomatic mounter that permits the operator to check the image on a 14 by 14 inch screen. The prepunched card contains selected information and all data cards are sorted and listed on an IBM 350 computer. The Concorde maintenance manuals and parts catalog will also be placed on microfilm.

4.3.1.2 Aperture Card Critique

Engineering drawings and data on aperture cards are being displayed in readers and reader-printers by some of the military services for maintenance information purposes. Volume production is not ideal since usually only one image is contained on a card. Also, the cards, to be efficiently handled, must be used with expensive automated equipment at large fixed installations and therefore are not suitable for portable or field use. Usually the aperture cards are stored in large trays and are retrieved individually by hand. The aperture cards, with the cumbersome traditional hand handling method, are being superceded by microfiche and roll-film concepts with their rapid multi-image film-based approaches. For additional information on this trend, refer to Boeing's new engineering drawing/data microfilm jacket approach described in paragraph 4.6.3.

4.3.2 Other Card Microform Systems

This portion describes two large (fixed base) microform card systems that could be employed for storing and presenting large amounts of technical manual information covering all maintenance levels. These are the MAGNAVUE and SELECTRIEVER systems. A third simple opaque card system called Microcard is also described.

4.3.2.1 MAGNAVUE System

MAGNAVUE is a large fixed system developed by the Magnavox Corporation for storage and retrieval of microfilmed information. This system combines proven microfilm methods for storage of graphic information with the recording of machine-readable data using photo-optic and magnetic techniques in a single-unit document storage medium.

The MAGNAVUE storage and retrieval system consists of: a rapid-access file for the storage of up to 675,000 microfilm images on mylar cards; a four drum card transport unit for automatically sorting, selecting and

purging the mylar cards; an associated copy and punch station for making
a Diazo copy of the image contained on a card and for punching the identifying
digital data into each copy card; and a data processor for making the logical
decisions required in the control of the MAGNAVUE equipment.

Figure 4.3.2.1 shows the 1-3/8 x 3-inch mylar card which is the basic
microform used in the MAGNAVUE system.   Each card contains a 1 1/4 by
1 3/4-inch area for the storage of the image.   Up to 150 alpha-numeric
characters are recorded on a magnetic portion of the card and up to 80
alphanumeric characters are permanently recorded on the card as black
and clear spots for photo-optical identification.   In the storage and retrieval of
microfilm images, the image portion of the card is used for storing a micro-
film copy of the relevant data.   The magnetic portion of the card is used to
record digital information for identifying this microfilm image, while the
permanently recorded portion of the card also stores identifying data but
in permanent form.

Requests in the form of identification numbers provide inputs to the system.
These requests are immediately answered by making use of the random
access capabilities of the file, and Diazo copy cards are made of each desired
microfilm image.   Requests are answered within 60 seconds of their
input to the data processor.

4.3.2.2   SELECTRIEVER System

The SELECTRIEVER System developed by the Information Systems
Division of the Mosler Safe Company is a random access retrieval system
that can accommodate up to 200,000 individual card size (3 1/4 x 7 3/8-
inch) documents.   The documents may be either aperture card, microfiche,
or even ordinary cards with written information on them.   This system is
used in a number of non-technical manual military applications.   However,
it could be used to store a hugh technical manual/engineering data
library in a fixed location for Depot and Intermediate level maintenance
usage.

1 3/8 x 3-INCH MYLAR CARD

RAPID ACCESS FILE

VACUUM SUPPLY

CONTROL UNIT

DATA PROCESSOR

TRANSPORT UNIT

IMAGE

PHOTOGRAPHIC CODE

CARD MOTION
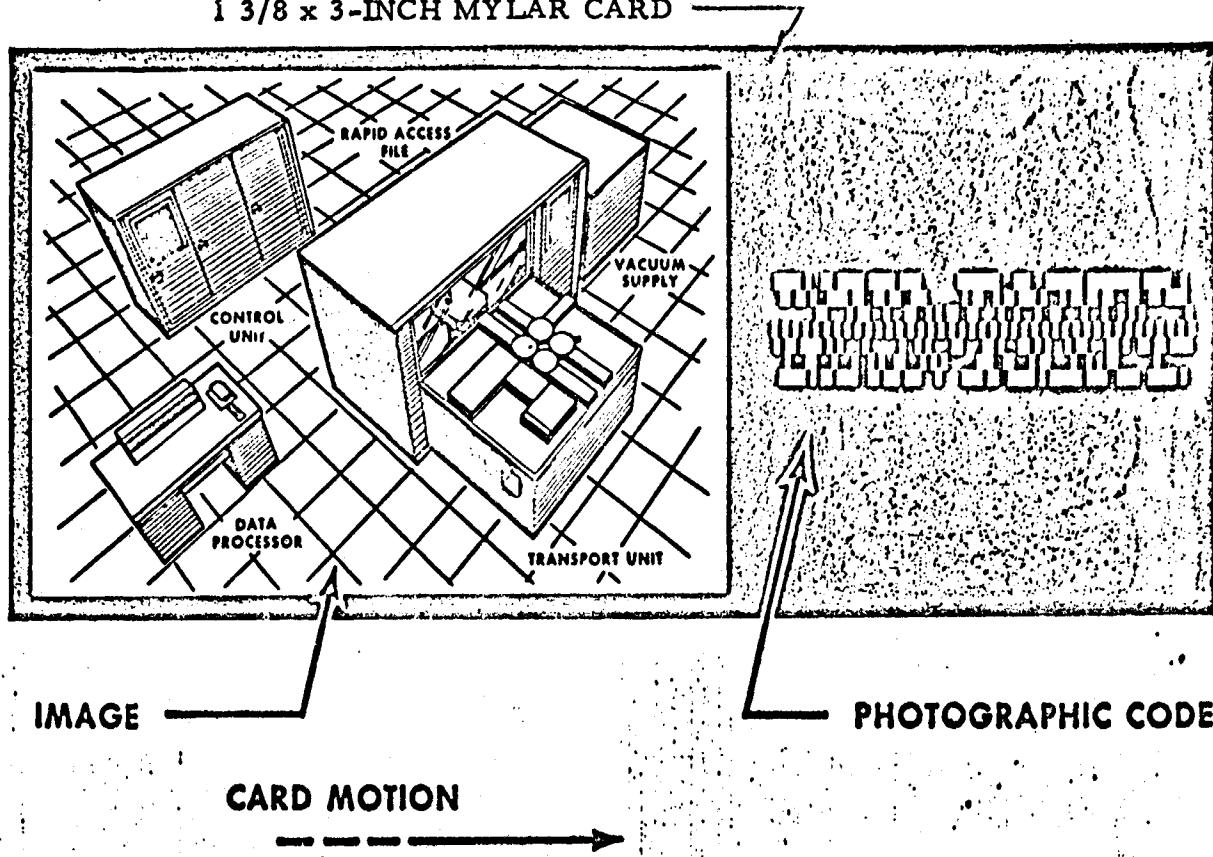
FIGURE 4.3.2.1 MAGNAVUE SYSTEM

US 4802 1434 REV. R-85

Figure 4.3.2.2 shows how the system handles information. The methodology for access is based on notches along the bottom edge of the card. Each SELECTRIEVER input card is coded with 35 round holes along the bottom edge. Specific holes are notched out to identify the card for automated handling. Punching and notching may be combined with the same operation that brings the cartridge which will store the card in the SELECTRIEVER. The cartridge has a capacity of 100 unit documents, and is housed in one of two parallel "honeycombed" walls, each holding 1,000 cartridges.

A lightweight cartridge retrieval mechanism operates between the two honeycombed walls. It moves at high speed to retrieve cartridges in response to commands entering the system via keyboard, punched paper tape, or computer interface.

The retrieved cartridge is automatically forwarded to a card-select unit (there may be several on one SELECTRIEVER) where the round holes in the cartridge and the card contents are engaged by the code mechanism. This device positively restrains all but the selected card.

The contents of the cartridges are then "fanned" over a stream of controlled-velocity air which first separates the adjacent cards from the selected card. This card is lifted, encased in a protective sheath of air, and either presented to the operator or run up into a platen in an optical path for automatic copying, projection, or image transmission, depending on the output chosen.

This system can store large-size graphic data (such as engineering drawings) and alphanumeric data (engineering change orders and technical manuals) intermixed in a single file module.

The retrieval of items of information from the file is accomplished automatically. In systems not computer controlled, the retrieval operation is performed upon entry of a unique document identifier (drawing, part number or technical manual number/page for example) at a keyboard

FILL ACCESS KEYBOARD NOTCHE

CLOSED CIRCUIT T.V.

REMOTE

A S T 3/8-inch.

Aperture Card

request-entry device. Computer control of a system permits the computer
to direct the system to retrieve a large number of technical manual pages
or drawings based on one request entry. Computer control also permits
requests to come from punched cards, magnetic tape and mark-sense cards,
as well as from keyboard terminals.

Indexing (edge-notching of file documents) and storage (infiling into the
information store) are accomplished automatically. The file operator enters
the document identifier at the keyboard, inserts the document into the
notcher, and then inserts that document into the cartridge which was
delivered to the file maintenance station simultaneous with the notching
operation. The cartridge is automatically returned to its correct location
in the file.

18 x 24-inch hard copy may be automatically produced at the central file.
In addition, 9 x 12-inch hard copy may be produced directly at remote
request/display stations. Retrieval time is 6. 5 seconds (average). Outputs
available include hard copy and television display and Diazo film duplicates
(card-to-card and card-to-roll). The system is equipped with 8-channel
time sharing logic elements so that multiple users have simultaneous access.
to information in the file.

4.3.2.3   Microcard-Opaque System

The Microcard system developed by the Microcard Reader Company (Now
NCR) employed 3 x 5-inch cards that contained up to 40 pages of conventional
technical manual pages (8 1/2 x 11-inch) photographed on each side (a total
of 80 pages per card). A reduction ratio of 1:18 was used and the opaque
cards are viewed in inexpensive National Cash Register (NCR) desk viewers
or hand readers, as shown in Figure 4, 3. 2. 3.

The Army Missile Command used Microcards in conjunction with the
Sergeant Missile System. In 1963, the Army faced the problem of finding

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a practical way to furnish the SERGEANT maintenance technicians with
the data contained on a very large number of computer printouts, some
38,000 pages. To publish the data in conventional Department of the
Army technical manuals, would have been very expensive, and the bulk of
the volumes would have been impractical to handle in shops and equipment
vans. The Army used microcards, reducing the images on 3 x 5-inch
cards. By this means, bulk was drastically reduced and so was cost.
The Army Audit Agency certified a savings of over a half million dollars.
The project adequately furnished the required data. The microcards
supplemented the standard technical manuals. They were used to trouble-
shoot the fault isolation equipment (including the computer) in the Sergeant
test vans. The text consisted of tabular data and line illustrations.

Reading printed technical manual pages on microcards is not as easy as
microfiche although opaque cards have a resolution factor of 100 lines/mm.
The user of the opaque-reader must view the screen from directly in front
of the screen, a disadvantage to the maintenance technician on the job.
However, the following microcard advantages should be noted. Technical
manual page changes/revisions and insertions are eliminated with micro-
cards. It is economical to reproduce the whole manual with each change.
The integrity of field information is assured, for the maintenance technician
merely discards the old card(s) once he receives the new card(s). The
maintenance technician can easily carry with him, in a lightweight (23 pounds
without carrying case) portable reader, all the necessary information
required to perform maintenance and may use a backup hand viewer in
confined areas or if the portable reader fails. Microcard images are
printed on an opaque surface and therefore cannot be read with other
microfilm viewing equipment.

4.3.2.4   AMF Microcard System

AMF, Incorporated of Santa Barbara also developed a simple opaque
microcard approach that is called AM File. It has four elements: a portable

viewer, microcards, matrix cards, and a sorting needle. The system has considerable flexibility in application. The card size can be varied to match a particular application. Second, the text and graphics on the microcards can be laid out in a more efficient format than the fixed sequential book sequence. To speed up the retrieval of specific information from microcards, AMF edge-patched each card. This permitted immediate retrieval of the microcard identified with a particular fault, component, sub-system or system. Next, the technical information was organized in a way that best met the user's need.

Using the principle of exclusion, AMF made available to the user only the information he needed, and blanked out all other information. This was accomplished by using another 3 x 5-inch overlay card called the "matrix" card. This card was edge-punched at the top to match the desired micro-card, and had apertures or little windows punched in it to show only the desired portions of the microcard. The matrix or masking card could also be color coded to identify the function being performed. In this way, there could be a separate card with different cut-out patterns for different types of functions (operation, maintenance, inspection, etc.). AMF demonstrated that the microcard maintenance information layout could be designed to eliminate much of the redundancy in the repetitive maintenance instructions, tool lists, and checkout procedures now found in conventional printed technical manuals.

4.4   FILM CHIPS/ULTRAFICHE

4.4.1   Introduction

High image density films that employ new technology have in recent years increased greatly the number of images that may be stored on microfilm. These new films are sometimes called film chips, ultrafiche or ultra-microforms (UMF). The high reduction ratios (over 100:1) of the ultra-fiche permit the number of images stored in a small space to range from thousands to millions of pages. For example, with a 300:1 linear reduction,

the resultant area reduction is 90, 000: 1. The following ultrafiche systems and equipment that are described include the National Cash Register PCMI system and Microform Data Systems' MINDEX/ULTRAFILM system.

4.4.2   PCMI Ultrafiche System

National Cash Register (NCR) has developed an ultrafiche approach called PCMI   (Photochromic Micro Image).   PCMI is a trademark of the National Cash Register Company.   The final ultrafiche product is a 4 by 6-inch transparency with up to 3,200 images represented on it in matrix form, as shown on Figure 4.4.2.   The transparency can be reproduced and inexpensive dissemination copies easily made.   Each dissemination copy is laminated in a plastic that precludes contact printing of any additional copies.   This controls unauthorized duplication and provides protection for the original publisher.

The following is a summary of some of the PCMI features:

- Although a 150: 1 reduction ratio is used, PCMI film positives are grain free and capable of high resolution (100 0 lines/mm).

- Retrieval requires first, that one knows which transparency to insert in the machine.   This requires a carefully planned index for the 3200 pages.   Second, each page has a left-hand bottom-edge index.   The LH index is the same for each page in the transparency.   Thus, it does not matter which page randomly appears when the transparency is first inserted.   The LH index tells which row contains the information.   The bottom-edge index tells which page in a row contains the subject material.   A simple X-Y control moves the transparency.   Retrieval is fast.   A demonstration, using the Ford Motor Company's Parts Catalog, showed retrieval of a given transparency required about 2 seconds.

U S 4002 1434 R F V . 8-55
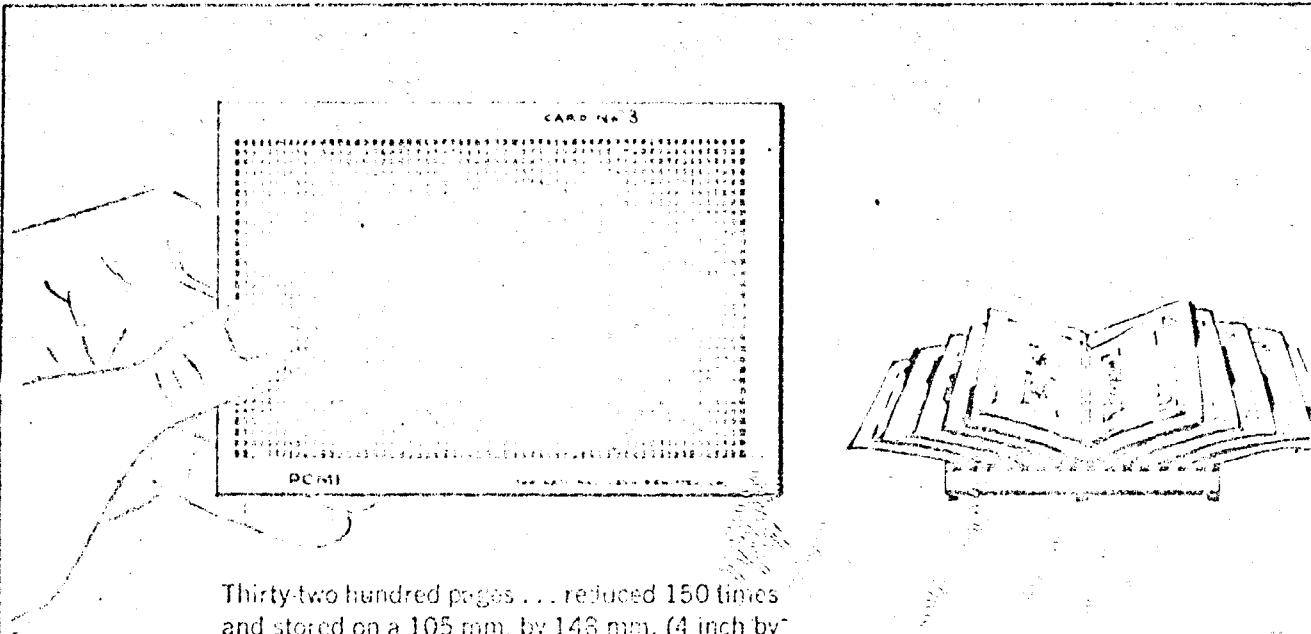
Thirty-two hundred pages . . . reduced 150 times
and stored on a 105 mm. by 148 mm. (4 inch by
6 inch) transparency. Both sides laminated for
ease of handling and protection of positive
images. Inexpensive dissemination copies pro-
vide information at point of use.

PCMI FILM CARD (3200 PAGES)

PCMI READER

- Excellent readability, free from dark spots.
- Clean from automatically resite dust.
- Easy to maintain.
- No **special** skills required.
- Dirt, scratches, scratches on transparency do not affect readability.
- Follow PMEI action.
- Location any of 3,200 pages in 1 second.
- 11 x 11-inch control screen.
- Weight 40 pounds.

- The viewer shown in Figure 4.4.2 displays the original size image. Clarity and resolution are good. The usual difficulty with ground glass screens is experienced. One must align his eyes normal to the image detail to avoid visual distortion. The viewers employ an easy-to-use line focus. Gross focus is automatically maintained. The 11 x 11-inch rear projection diffused surface screen can be used without difficulty in a well-lighted room.

- High Density Storage is an attractive feature. The 150:1 reduction allows a total of 3220 8 1/2 x 11-inch pages per 4 x 6-inch transparency. A total of 153,600 8 1/2 x 11-inch pages can be stored in a cubage of 4 x 6 x 1-inches.

- Transparencies will withstand temperatures up to 175° F. Readability is not degraded by scratches, dirt or grease.

- Cost of a PCMI Master is $400 for set-up plus $0.15/page. A 3220-page master costs $883.00. Viewing copies cost $1.00 each.

- Readers cost approximately $700 in commercial form. A Mil-Std version has been environmentally tested by the Naval Supply Systems Command. (Cost of the Mil-Std version was not available.)

- Reader size is 26 x 16 x 24-inches and weight is 60 pounds.

The steps utilized in forming PCMI transparencies are as follows:

- Camera-ready reproducible technical manual copy organized according to a detailed index plan is required.

- A 15X reduction is made on 35mm stock high-quality microfilm.

- The 35-mm copy is fed to an NCR Camera Recorder where it undergoes a 10X reduction.

- With appropriate filtration, near ultraviolet light is directed through the transparent microfilm and into micro-image optics, forming a miniature image on the photochromic coating.

- By a step-and-repeat process, multi-image matrices of these miniature images are formed.

- The matrix is then transferred to high-resolution photographic emulsion by contact printing.

- The photographic emulsion is developed under controlled conditions, resulting in a 4 by 6-inch photochrome dye master film positive.

- A contact negative is made (up to 5 negatives can be made from one master).

- Contact printed film positives are made from the negatives. These positives are laminated between protective sheets of material.

For full automation, with document storage in the millions of document pages, the NCR system uses an automated file and an automated viewer. The file and viewer are controlled by a general-purpose or special-purpose computer. In the fully automated system, a search is instituted in the computer for documents matching specific search parameters. When a match is made, the location of the document is transmitted to the PCMI system for automatic retrieval of the card and automatic positioning of the viewer table.

Viewers provide enlargement of the micro-image to approximately the original document size for screen viewing. This approach provides the following additional output features, where required.

- A full-size hard-copy printout may be obtained using standard photographic techniques.

- A standard microfilm (16mm or 35mm) of the micro-image may be obtained, using standard photographic techniques. The microfilm may then be used as input to other standard techniques, e.g., xerography or copy flow printing.

4.4.3   Microform Data Systems (MDS)

An ultrafiche or film chip system, developed by the Republic Aviation Division of Fairchild-Hiller, was initially used in the Air Force PIMO technical manual improvement program (paragraphs 6.2.4 and 6.2.6.2). This program employed 2 x 2-inch laminated photographic film chips, each containing approximately 9800 8 1/2 x 11-inch C-141A aircraft technical manual pages. The information images (pages) were arranged on each chip in a 99 x 99 matrix. These images were randomly retrieved electronically by a digi-switch and viewed in a 5 1/2 x 5 1/2-inch screen in a portable lightweight viewer. In mid-1968, Microform Data Systems of Palo Alto, California acquired all patent rights of this "Micro-Vue" System from Fairchild-Hiller and has since developed improved automatic readers called MINDEX (trade name) that employ "ultrafilm". Figure 4.4.3 shows how "ultrafilm" compares to other media relative to storage capacity. The MINDEX readers employing the ultrafilm media, could be used for the storage and retrieval of maintenance information. The MINDEX can be used as a stand-alone random access storage device, or equipped with an internal video display attachment and connected to a local or remote computer system. When used to complement a computer system, the MINDEX can provide random access to a large file of static information stored in the reader.

Other standard features include:

- Storage Capacity: 20,000 records or pages (8 1/2 x 11-inches) at 210X.

- Access Time: Sequential, less than 1.0 seconds; Random, 3.0 seconds; Average, 6.0 seconds maximum.

- Ultrastrip Storage: 10 internally stored ultrastrips are standard. Easy file replacement and updating are featured.

- Screen Size: 12 x 12-inches.

- Weight: 90 pounds

- Controls: 10-key numeric keyboard, on-off, page forward/page back.

THE *BOEING* COMPANY

ULTRAFILM STORAGE COMPARISON

ULTRAFILM

OTHER MEDIA

A stack of 8 1/2" X 11" documents more than 7" high. End to end, these would equal the length of six football fields (1800').
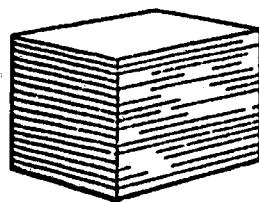
More than 60' of conventional 16mm microfilm.

A single 6" ultrastrip weighing less than a gram.

33 COSATI microfiche.

Contains up to 2,000 8 1/2" X 11" pages of data—more than ten million characters of information . . .
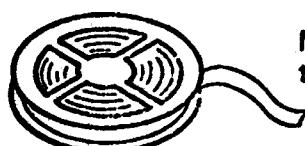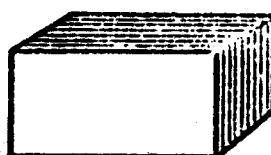
Two magnetic storage disk packs.
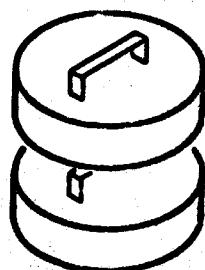
One 2400' reel of magnetic tape.
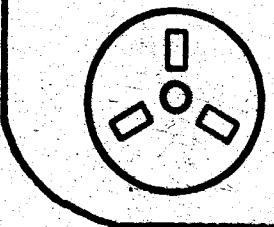
FIGURE 4.4.3   ULTRAFILM STORAGE COMPARISON

US 4002 1424 R F V . 9-65

Special additional features include:

- Printer Attachment: Electrostatic printer (10 seconds print time).

- Additional Internal Storage: Available in three increments for a total of 40,000, 80,000 or 120,000 records (pages).

- Display Attachment: Internal video display unit with computer interface.

- Computer Attachment: Provides input to local or remote computer from numeric keyboard.

Updating is accomplished easily and economically by simply replacing ultrastrips. Since a single ultrastrip contains up to 2,000 records, there are fewer replacements per update (replace only one ultrastrip instead of twenty conventional microfiche) and the cost of updated conventional microfiche can be cut up to 90 percent according to Micro Data Systems.

4.5   MICROFICHE

4.5.1   General Information

Microfiche, which is sheet film in the form of a film card, usually measures approximately 4 x 6-inches. Microfiche is a French word meaning collection of data in a small package. Two standard reduction ratios are widely used --- 20:1 and 24:1. The 20:1 COSATI (Committee on Scientific and Technical Information) standard microfiche contains up to 60 pages (8 1/2 x 11-inches). The 24:1 NMA (National Microfilm Association) commerical microfiche contains up to 98 pages. An eye-legible heading includes the classification or identifying number, document title, source and other basic identifying information.

Microfiche (or fiche) may be produced with either positive images (black image on clear background) or negative images (clear images on black). If hard copy printout is a major requirement, negative fiche are used to give a black on white paper copy, since the image is reversed in processing. If material contains a large number of photographs, positive fiche are indicated for reader scanning, since it's difficult to interpret a negative

image photograph.

In general, any standard system of classification and indexing can be applied to microfiche. A variety of automated and semi-automated retrieval equipment is available, and since the microfiche heading is eye-legible, hand filing is widely used. Edge notch systems for direct needle sort are applicable (paragraph 4.3.2.2 describes the Mosler SELECTRIEVER "needle-sort" system) and reduce the title block area only about 1/4". Such basic devices as upstanding tabs or selective filing contours can also be used to simplify filing in the proper subdivision.

Microfiche is the fastest growing microformat! At a joint meeting of the Aerospace Manufacturer's in Seattle, Washington at the Boeing Company on 6 December 1968, it was predicted that microfiche would replace aperture cards in the engineering drawing field. The Federal Government has selected microfiche as the standard for agency technical data distribution systems. Fifteen million microfiche will be distributed by the government this year. At the beginning of 1969, the National Microfilm Association forecast an 18 percent increase in dollar volume for the industry for the year, a volume reaching toward $400 million.

4.5.2   Microfiche Characteristics and Advantages

The Bell and Howell Company, that markets a full complement of micro-film systems including roll film, cartridge rolls and microfilm jackets, has also been one of the leading proponents of microfiche. Their recent emphasis on this microformat is founded on the following characteristics and advantages:

Quality   Microfiche exceeds quality standards of roll or cartridge film. Line drawings and schematics require high resolution in viewing and printing. Resolution measures from 140 - 180 lines per millimeter.

Design
Simplicity
(Equipment)

This is an important factor in flight-line and shop maintenance operations. Individual page retrieval that operates similar to present look-up techniques results in quick user transitions. Equipment is low cost and rarely inoperative. Portable battery readers insure a 100% operational system.

Flexibility

A complete family of readers and reader/printers is available. The difference in microfiche equipment versus cartridge units permits taking the system to the users. More viewing units can be provided which saves valuable time.

Drawings and schematics can also be microfiched. Readers with 14 x 20-inch screens project a full "B" size drawing. Revisions can be made as they occur and not as dictated by cycles or economy factors.

Continuing hard copy print costs are as much as 50% lower than 16mm cartridge systems.

Reader/printers provide positive prints from either positive or negative film.

Individual units of maintenance information are always accessible and not grouped with hundreds of others as with roll film. Additions to the main body of information can be interfiled easily and obsolete data removed.

Information is available in small, easy-to-manage units. The average technical manual is 160 pages in length and can be reproduced on two microfiche.

Distribution

Microfiche is the least expensive and less troublesome. No cartridges to return for re-loading, no labels to be peeled off for new indexing. Regular size envelopes are used for most distribution applications. Replacement is almost immediate and revisions are fast and simple.

THE *BOEING* COMPANY

Futuristic Concept   The microfilm industry is currently spending large amounts of research dollars in microfiche systems - not in cartridge programs. For the last two years, the National Microfilm Association's (NMA) annual convention has been dominated by microfiche equipment and systems applications supporting this microform.

In addition to the general advantages just cited, there are other microfiche advantages relating specifically to technical manuals. Within the basic microfiche format there is considerable flexibility! The size and type of photographed material placed on the microfiche can vary, as indicated in the illustrations provided in Appendix A in the rear of this document. Either 16, 35 or 105 mm film, or a combination of these sizes, can be used on one microfiche. For instance, a D-size engineering drawing on 35mm film can be incorporated on a microfiche composed otherwise of 16mm film. See Appendix B for a microfiche characteristics checklist.

Technical manual fold-out diagrams of any length can be filmed on microfiche using flow cameras. Thus, a 16mm flow camera can film on microfiche a schematic diagram up to 12-inches high of any length. A 35mm flow camera can film a diagram of up to 24 inches high of any length. A schematic diagram approximately ten feet long can be reduced to one row on a single microfiche. Also, computer-generated data on microfilm (COM) can be placed on microfiche. High speed microfilm cameras can film up to 15,000 lines per minute.

The following paragraphs describe a number of microfiche systems including the U. S. Army's Microm system and IIF Image Systems' automatic CARD microfiche system. Numerous other microfiche systems/equipment are listed in the Appendix in the rear of this document.

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4.5.3   Army MICROMS Microfiche System

4.5.3.1   Introduction

MICROMS is an acronym for Maintenance Information Concerning the
Repair and Operation of Missile Systems. This system features the
storage of technical manual information on microfiche, unique indexing
and format methods, and manually-operated, rugged, portable microfiche
readers designed for field use. This system was developed in-house by
the Supply and Maintenance Directorate of the U. S. Army Missile
Command, Redstone Arsenal, Alabama. The Army Missile Command
has been active in experimental work on military technical manual micro-
format applications since 1963 and has pioneered numerous successful
microfiche technical manual applications. They also have developed
successful 16mm maintenance information display systems such as the
FLATTOP and EDS programs (paragraph 3.4.3.4 and 3.4.3.5).

Major General Charles Eifler, in the foreward of the August 1969 U. S.
Army MICROM Report (Reference 23), states: "From what has been
learned (in the MICROM studies), it appears that microfiche is ready
to take over part of the job of supplying maintenance information". This
report cites the following four major technical manual problems that
led the Army to actively move ahead with the MICROM program:

Space   Most of the Army's modern support equipment is
                     mounted inside compact vans. Many of these vans do
                     not have the space to store the manuals properly.

Retrievability   As the size and number of technical manual volumes
                     grow, it becomes harder and more inconvenient for
                     the technician to find what he needs, and to make use of
                     it efficiently. Sometimes, the manual he needs is not
                     in the van and he has to go after it. Then, there may
                     not be adequate table space to use the technical manuals.

He may have to improvise, perhaps spread them out on his lap. There is also an adverse psychological factor. The Army asks: "If it's inconvenient to dig out information, will the technician go to the trouble?"

Concurrency

There are two aspects to the problem of keeping technical manuals up to date. First, it takes the Army from one to six months to print and distribute a change to a manual. (The average time was recently running over 100 days). Second, it's trouble and it takes time to insert change pages in a manual. This becomes quite complicated when only certain serial numbered equipment and modifications to equipment are involved. It's possible to make mistakes. Present technical manual updating methods are inefficient and time consuming to a serious degree.

Cost

The Army has an 84 million dollar collection of technical manuals. Printed manuals are expensive to print, ship, handle, and store.

Thus, the Army investigated various microfilm media and concluded that microfiche will alleviate the space, retrievability and concurrency problems just cited. They also feel that microfiche could substantially reduce maintenance information costs.

The Army also considered numerous new techniques currently available for storing and retrieving operation-maintenance (technical manual) information by computers, but concluded -- "at this stage, they appear too exotic and complex for field usage" (Reference 23). Thus, for the present, microfiche appears to be the practical answer for the Missile Command of the U. S. Army. They investigated film chip (ultra fiche) aperture card, microcard and roll film concepts before selecting microfiche. Roll film was a strong competitor but had these disadvantages:

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* Difficulty of indexing data

* Cost of updating - to update a single page, it is necessary to distribute a new 100-foot roll (2600 pages) to each user.

* Viewing equipment is relatively bulky, heavy, and expensive. Equipment was not readily adaptable to compact quarters.

* Flexibility of format limited.

Microfiche was finally selected in the MICROMS program for a number of reasons, eg, economical to produce and change, flexible format, and viewing equipment was less builky and expensive and more adaptable for use in compact quarters.

4.5.3.2　　　　　　　　　　　MICROM System General Description

The goal of the MICROMS project was to develop a portable maintenance information presentation system that would be simple and economical to operate and maintain. The maintenance information was placed on NMA 4 by 6-inch microfiche, using a reduction ratio of 24:1. The pages were arranged in a grid-zone pattern, with 14 frames horizontally and 7 frames vertically. Any frame could be quickly located manually. The pages, or frames, were laid out functionally on each microfiche. The frames on the top horizontal row were usually labeled as follows:

Index	Test Setup	Checkout Procedures	Troubleshooting		Circuit Schematic		Theory of Test		Exploded View	Parts List			Repair Parts
1	2	3	4	5	6	7	8	9	10	11	12	13	14

A

B

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For instance, a maintenance technician could find the detailed checkout procedure in column 3. The technician's eye would simply run down the appropriate column as he looked for information, set up tests, or performed checkout procedures. Closely associated information - such as trouble-shooting instructions for a certain procedure, or circuit schematics and their theory - could be laid out horizontally, side-by-side, in a closely linked manner. If the maintenance technician was routinely performing the checkout procedures tabulated in the appropriate column and had a bad response, he looked at the reader screen and immediately adjacent to the checkout procedures he could view the appropriate troubleshooting procedures. The troubleshooting procedure may have been involved, requiring the technician to read the theory and consult circuit schematics for an understanding of the trouble indicated. If so, he simply moved the microfiche two frames to the right. Appearing on the reader screen, side-by-side, would be the appropriate circuit schematics and their theory.

The Army also developed other microfiche format arrangements including the following·

Horizontal - In this format the technician proceeds downward from the top, following step-by-step procedures. When he runs into trouble with his equipment, he moves laterally for theory and schematic diagrams and other troubleshooting and repair information. Instead of slipping to a different chapter in a book, he merely moves a few images to the right, or left. On a single microfiche, this format can provide the information in a 75 to 80 page book.

Vertical - In this format, the technician reads left to right, conventionally, but starts in the middle of the microfiche. He then moves up or down for certain types of supplemental information. Again, he has on one sheet, in integrated format, the information contained in a 75 - 80 page book. In most cases, the complete checkout and repair of a chassis, including repair parts information

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can be contained on a single microfiche.

The Army evaluated a large number of commercial readers and reader-printers and found none suitable for the Army's field environment. However, some of the commercial equipment was suitable for use at large fixed Army maintenance installations, and pilot studies of microfiche at the depot level were conducted at the Pueblo Army Depot in Colorado in 1966 that is described in paragraph 4.5.3.7. The commercial equipment evaluated for field usage was rejected for a number of reasons. Most of the commercial equipment was too bulky and too fragile for portable usage, and none was found that would operate from the 400 cps power sources used in equipment maintenance vans. Some of the other qualities that the Army required in a reader-printer for field use were:

- Two-page display viewer small enough to be rack mounted in a van.

- Alternative operation of viewers from DC power sources.

- Hardcopy printout to original size without wet chemicals.

Since suitable commercial equipment was not available, the Army developed a number of new readers and reader-printers that are described in paragraph 4.5.3.5. Concurrent with the equipment development efforts, the Army developed many successful maintenance information microfiche layout approaches, some of which are described in Appendix A. They were intrigued by the layout possibilities inherent in microfiche. The Army discovered that it was possible to rearrange maintenance information so that the technician progresses up or down with as much ease as forward and backward. The Army Missile Command argued that microfiche, because of its flexible format possibilities, had a greater potential than printed technical manuals or any other micro medium relative to the development of highly interrelated and rapid-access maintenance information systems. They stated that microfiche is really a new maintenance information display or art form!

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4.5.3.2   Microfiche Booklet Concept

In the MICROMS SERGEANT field tests, a unique microfiche booklet
concept was developed. All the maintenance and repair part information
pertaining to a related group of maintenance jobs was bound together in
one booklet or packet which could be slipped into a jacket pocket. Thus,
the technician could proceed to his remote working area confident that
he had all the data he needed.

·Figure 4.5.3.2 shows the microfiche booklets and the simple ring binder
developed by the Army. It was not necessary for the technician to remove
the desired fiche from the ring binder. A rack on the Army-developed
MICOM viewers supported the booklet while the user views the selected
fiche. Besides convenience, the booklet method keeps the fiche in proper
order and reduces the chance for loss of individual fiche. Also, each
booklet had an eye-readable index cover that listed the contents of
the given booklet. Thus, a technician with a 12 fiche booklet could be
carrying up to 1176 technical manual pages in his jacket pocket. Other
microfiche programs have developed similar fiche-pockets. Some employ
heavier covers to protect the microfiche, and by use of colors and cover
markings, segregate classified and special task-oriented fiche-booklets.

4.5.3.3   Microfiche Filing and Indexing

The SERGEANT missile system used small metal tub files. One
commercially available 6 x 8 x 10-inch file used had a capacity for 160 fiche
and held all of the maintenance information contained in the 91 technical
manuals on the SERGEANT missile system. A standard 23-inch tray will
hold the equivalent of 64,000 pages of information. Four of the 23-inch
trays will hold all of the published technical information on HERCULES,
the Army's largest fielded missile system.

USE FOR TYPEWRI 4 MATERIAL ONLY

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RING BINDER TYPE

MICROM MICROFICHE BOOKLETS

COVERS
COLOR
CODED
PER
SYSTEM/
FUNCTION

STIFF FRONT
AND BACK
COVERS

SINGLE RING TYPE
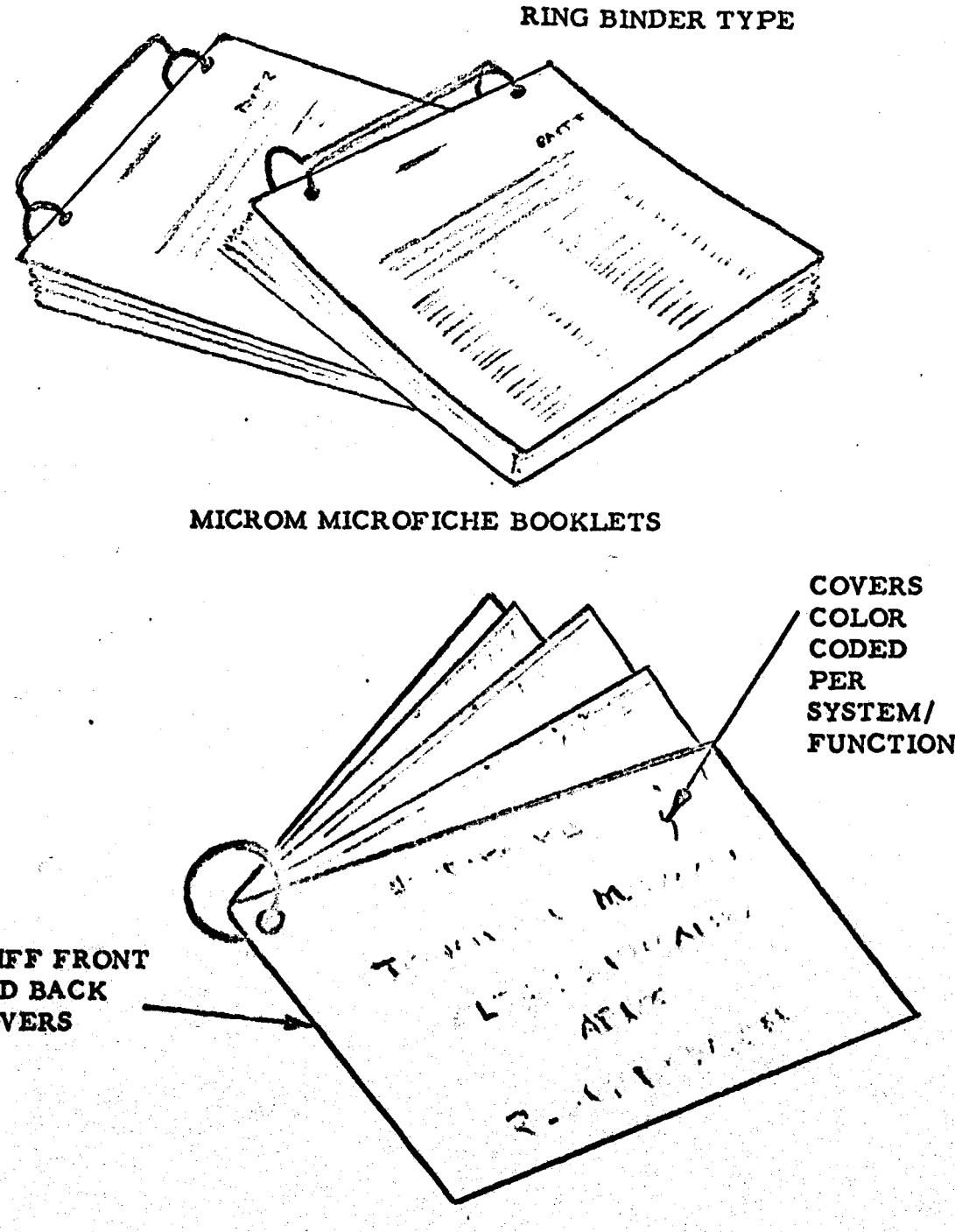
FIGURE 4.5.3.2 MICROFICHE BOOKLETS

Eye-legible index cards, in the front of the SERGEANT missile system
file tray, listed the fiche technical manual titles, technical manual
numbers, and the equivalent microfiche numbers.   Each 4 x 6-inch (same
size as microfiche) removable eye-readable index card was arranged
as follows:

Table of Contents		W. S. Title
Tech Manual No.	Title	Microfiche No.

(Approximately 30 manuals (or microfiche) were listed in

double columns on each card).

As the fiche are filed in numerical sequence, it is only necessary to
determine the number and go directly to the desired fiche. When the
fiche has been selected by the technician, it is placed in the viewer
on image A1.   Image A1 gives the contents of the fiche and location by
grid number.

4.5.3.4   Microfiche Updating

The Army's time-consuming and burdensome updating problems with their
technical manuals were almost eliminated when they employed microfiche
in the SERGEANT program.   Since the master microfiche is made up of
short, replaceable 16mm strips of film, only the strips involved in a change
need to be rephotographed.   Consequently, it is practicable to furnish a
complete new fiche whenever a change is required. And whenever more
than one configuration of equipment is involved, it is practicable to
furnish fiche for each configuration.   There is no bulk and very little cost
involved.   Only a short time and a few cents worth of materials are required
to produce a new working master, and copies can be produced for as little
as 14 cents each.

When a technician receives a new fiche, he simply inserts the new fiche
in his file and destroys the old fiche. In this single operation, he has
done the equivalent of inserting hundreds of printed replacement pages.

4. 5. 3. 5   MICROMS MICROFICHE EQUIPMENT
                     DEVELOPMENT

4. 5. 3. 5. 1   Introduction

The Army Missile Command found that the commercially available micro-
fiche readers (viewers) and reader-printers were unacceptable for their
field use (paragraph 4. 5. 3. 2) and developed their own microfiche
equipment. A statement is in order at this point relative to the Army's
use of the words "viewer" and "copier". The Army uses the term
"viewer" interchangeably with the NMA term "reader", and "copier"
interchangeably with the commonly used term "printer". The Army
initially developed a standard microfiche reader "handler" (paragraph
4. 5. 3. 5. 9) that is interchangeable between the various two-page, one-
page and half-page readers described in the following paragraphs. These
Army equipment descriptions were derived from MICROM reports
(Reference 23).

4. 5. 3. 5. 2   Model 18V Reader

Figure 4. 5. 3. 5. 2 shows the MICROM model 18V reader (viewer) and
model 18C piggy-back attached printer (copier). The model 18V shown,
ready for transport with covers installed, weighs 48 pounds and measures
18 1/2-inches wide, 21-inches high, and 22-inches deep. A breather valve
in the case protects the viewer in case of rapid changes in altitude. The
front cover of the case, which is removed for viewing, has a fiche storage
compartment and a bracket for storing the power cord. The model designa-
tion 18V is derived from the 18-inch diagonal measurement across the
viewing screen.

The 3M Company developed the Fort Sill test prototype 18V readers and
other MICROMS readers and the 18C printer in accordance with Army
requirements (design performance and technical characteristics).

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Standard Microfiche Handler

18V Reader in Use   Feeder Ready for Transport

The reader or viewer displays two standard 8 1/2 x 11-inch (kingsize) pages side by side on a 10 x 15-inch screen, using fiche filmed at a reduction ratio of 24:1. The viewer is equipped with three lenses of different magnifying power: 20.7X, 24X, and 36X. Two are mounted in a slide and the third is stored. Assume that the 20.7X and 36X lenses are mounted in the slide and that the user, viewing an exploded-view illustration, desires to see a particular area of the illustration in more detail than provided by the 20.7X lens. He simply moves the lens slide horizontally, automatically inserting the 36X lens. The desired area of the illustration is now seen at 1 1/2 times the original size.

Although the viewer is designed primarily for viewing microfiche, roll film can be viewed by the use of a simple manual adapter which could be motorized if necessary.

The viewer may be used either with or without the reader-copier. By having the viewer and copier as separate units, the versatility and practicability of the viewer is increased as it may be employed without the added expense and space requirements of the copier in situations not requiring a copying capability. When the copier is used, both the front and bottom covers must be removed.

4.5.3.5.3   Model 18C Printer (Copier)

The 18C printer (copier) shown in Figure 4.5.3.5.2 is ready for transport and ready for mating with the 18V reader (viewer). In the transport mode, the copier weighs 75 pounds and measures 18 1/2 inches wide, 12 1/2 inches high, and 22 1/2-inches deep. Power requirements are 115v ac and 50, 60 or 400 cps. The size of the copied image is 8 13/16 by 15 inches. Image blowback ratios are 20.7X, 24X and 36X. Copy cycle time is 15 to 30 seconds. The copy paper is 3-M dry-silver paper, furnished in 15-inch wide, 400-foot rolls. One 3-M roll yields approximately 480 copies.

The viewer is secured rigidly to the copier by two clamps at each side and at the back in a light-proof junction. Separate switches permit the operation of the viewer only, or the viewer and copier. During the copying cycle, a mirror, positioned at the rear of the light chamber to reflect the image to the viewing screen, moves forward out of the light path. This allows the image to be projected downward to the light-sensitive paper in the copier unit. After exposure, the paper is automatically passed over a heater drum, cut, and delivered out the exit chute in the front of the copier.

4.5.3.5.4   Model 14V Reader

The model 14V reader (viewer) shown in Figure 4.5.3.5.4 is equipped with a 24X projection lens and displays one full page on an 8 1/2 x 11-inch screen. It operates on ac or dc power sources. Overall dimensions, with hood retracted, are 9-inches wide by 17-inches high by 11-inches deep. With hood advanced, the depth is increased 7 1/2-inches. The purpose of the hood is to improve readability of the screen under conditions of bright light.

4.5.3.5.5   Model 9V Reader

Figure 4.5.3.5.4 also shows the MICROM half-page model 9V reader (viewer) ready for use and also closed -- ready for transport. This small reader or viewer is designed to be readily portable and to take up a modest amount of space when in use. It is equipped with a 24X projection lens and displays approximately one half of a letter-size page on a 4 by 7 1/2 inch screen. The removable metal case protects the viewer during storage and transit and under severe weather conditions. The viewer, without case, weighs 17 pounds and measures 13-inches wide by 9-inches high by 9 3/4-inches deep. The model 9V reader was modified to produce the one-page model 14V reader which has proved more suitable when the highth dimension is not critical.

The Army recognized that microfiched technical manual information
should be proofed and used in the training and early test programs. Thus,
they developed the classroom projector shown in Figure 4.5.3.5.9.
The Army felt that the microfiched technical manual information should
be readily available for projection on a screen in the classroom. They felt
that this would be particularly useful for certain types of exercises with
schematic diagrams such as signal tracing and theory development. The
projector shown is a prototype model developed to demonstrate the
feasibility of the concept as applied to 98-frame NMA microfiche. The
projector measures 5 by 8 by 10-inches and throws a 3 by 5-foot image
of good legibility at 15 feet. The Army feels that this is a microfiche
equipment item that has a considerable potential in future training/
technical manual applications.

4.5.3.5.7   Microfiche Hand Viewers

The Army realized that small hand microfiche viewers would be useful
in emergencies. There are several pocket-size viewers on the market
but they have a smaller field of view and lower magnification than is
desirable for the 24:1 reduction ratio that is characteristic of NMA
microfiche. Thus, the Army built a number of pocket-size viewers with
a 24:1 reduction ratio. These models are still under development.

4.5.3.5.8   MICROM Table-Top Reader Developments

The Army feels that one of the most promising fields for development is
offered by the table-top concept. It is especially suitable where space
is at a premium, as in military and commercial equipment servicing vans.

The Army initiated research in this area of built-in desk and wall
viewers, as shown in Figure 4.5.3.5.8. The projector the Army selected
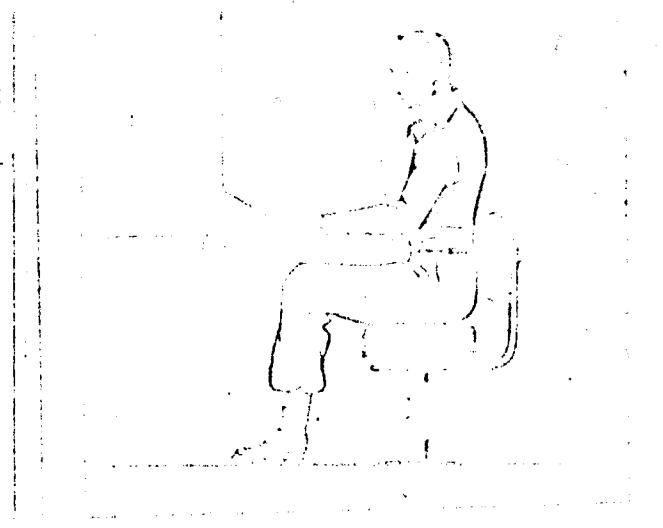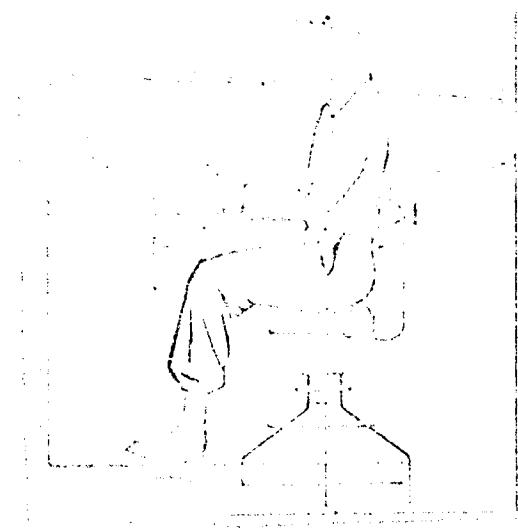
TYPICAL TABLE-TOP APPLICATION

for use in several van installation- is essentially the base assembly of
the other Army readers previously described, adapted to mount under a
bench or table top. The image projects through a hole in the bench top,
or to the rear or side, to an external mirror. From the mirror, it projects
to an external viewing screen or surface that is convenient to the operator.
The arrangement is variable to suit the van configuration. The size of
the projected image can be varied for the individual installation.

4.5.3.5.9   MICROM Standard Microfiche Handler

The top illustration on Figure 4.5.3.5.9 shows the unusual microfiche
handler thàt the Army developed and is used in all of the Army MICROM
readers described, including the table top viewer. Although the film
handler is a precision instrument, it is rugged and can be mass-produced.
The carriage slides on teflon rods and has both coarse and fine adjustments
for rapid location of desired image and pinpoint tuning. The lens focus is
also adjustable.

The film handler is used as follows after attachment to the reader.
After the microfiche is placed on the lower glass, the upper glass is
lowered and held against the fiche by spring clips at each side. To obtain
a desired screen display, the upper portion of the handler (X carriage) is
moved to the left or right and the lower portion of the handler (Y carriage)
is moved toward or away from the operator. When the release lever on
the front of the handler is in the lower position, the carriages can be moved
freely and rapidly. When the lever is in the upper position, as shown in
Figure 4.5.3.5.4, a frame image may be precisely positioned by use of
two vernier controls on the front of the handler. A microfiche booklet
support can be attached to the front of the handler to support a booklet of
fiche (see paragraph 4.5.3.2).
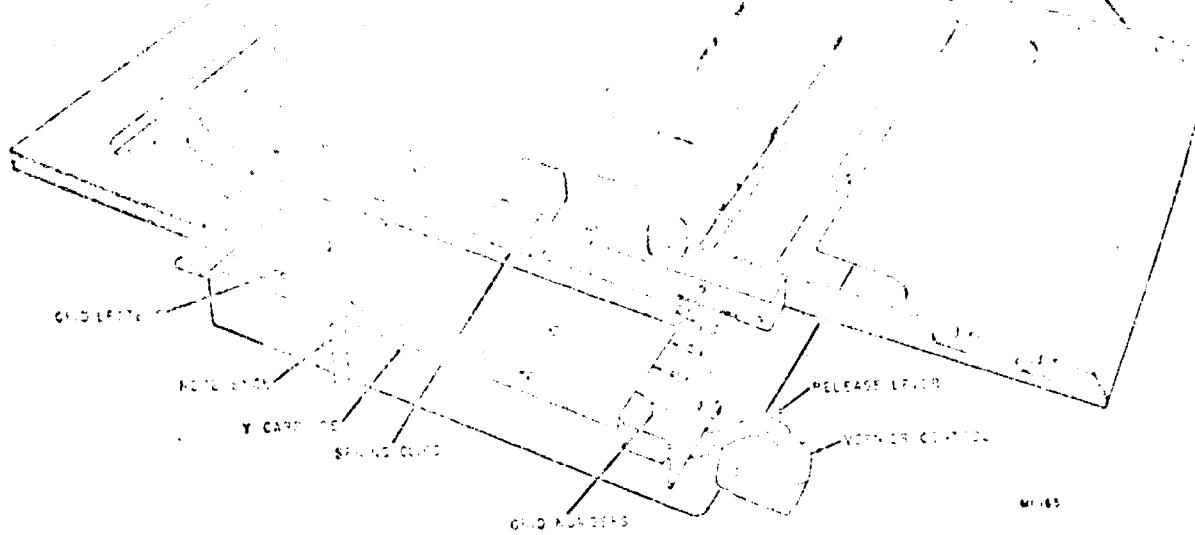
CARD AND MOUNTING HANDLER.

4.5.3.6   MICROMS Microfiche Equipment
                          Test Criteria

The Army developed a number of environmental tests for the field-oriented microfiche equipment they developed in order to evaluate the ruggedness of the equipment. These tests were conducted by the Brown Engineering Company of Huntsville. Each of the tests was designed to subject the equipment to a particular set of extreme environmental conditions. There were eight tests: temperature cycling, altitude, rainfall, thermal shock, humidity, vibration, sand and dust, and mechanical shock. After each test, an operational check of the equipment was made.

These microfiche equipment tests conducted by the Army are leading the way to improved rugged and proven equipment that will be useable by all the military services and the industrial world under severe environmental conditions. The detailed MICROMS test specification and results should be consulted by all interested in developing improved field type microfilm systems.

The microfiche equipment failures that were noted are considered minor, and readily correctable in production models that will follow the developmental equipment that was tested. For example, corrosion in attaching hardware will be corrected by using hardware with anti-corrosive plating. Leakage of water can be corrected by properly bonding the water seal. The one failure not immediately correctable - the partial development of the paper - is not of consequence because exposure of the equipment to a temperature of 150° F is not a probability under foreseeable field environments. In the two most significant tests, vibration and mechanical shock, performance exceeded that to be expected of items of test equipment in the vans.

4.5.3.7   MICROMS Microfiche Depot Tests

A pilot study of microfiche at the depot level was established at Pueblo
Army Depot, Pueblo, Colorado in January 1966. The SERGEANT
missile system was selected for the test. As instructions for overhaul of
items were developed, they were put on microfiche instead of being
printed as technical manuals. A special format was devised for the
information going into the microfiche. The format aimed at making
the microfiche as easy to use as possible and at standardizing the
arrangement of information. The A-G 1st vertical column of the
microfiche contained the following categories of information:

       A - Introduction - Tools
       B - Test
       C - Test - Troubleshooting
       D - Troubleshooting
       E - Theory Repair Parts
       F - Maintenance - Final Procedures - Contractor Maintenance
       G - Contractor Maintenance

There was another difference between the fiche and the conventional
overhaul handbooks. This was the incorporation into the fiche of all
supporting information from other sources such as technical manuals,
drawings, etc. Reference to other documents was eliminated by this
means and the technicians were relieved of the chore of gathering up
several different documents in order to do a job.

In printed technical manuals, it is customary to make reference to other
documents. The expense and bulk that would be involved in providing
everything needed in one package of printed matter would be prohibitive.
Neither expense nor bulk were prohibitive in the microfiche. In fact,
the expense was less for the fiche program than it would have been for
a conventional printing program.

When information in a fiche required change, a replacement fiche was issued to the depot. This eliminated the inserting of individual replacement pages, as is done in printed handbooks. The equivalent of 281 depot handbooks, totaling 16,516 pages, were put on microfiche for this test. Twenty sets of fiche were furnished the depot for each procedure. Specially designed viewing and copying equipment was not employed. Off-the-shelf commercial microfiche viewers and copiers were used.

The tests were successful and recommended that the handbooks for all the missile systems be put on fiche. The improved format of the SERGEANT fiche was considered satisfactory and the fiche were found to reduce information retrieval time. The Army developmental viewing and copying equipment described previously was also recommended but commercial equipment proved satisfactory and could be used in future programs in Depots.

These Army overhaul tests are described in greater detail in a Boeing Logistics Technology Staff companion document to this volume covering the Boeing MORETS Program. Information on how the MICROM Depot information was indexed and related to specific overhaul tasks was not available in the Army reports available. However, this data indexing/ job assignment relationship information is being obtained and will be discussed in the document covering the new Boeing MORETS microfiche program.

4.5.3.7.1   Boeing MORETS Program

MORETS is an acronym for Microformatted Overhaul Road-map Engineering information/Technical manual System that is under development by the Boeing Aerospace Group. This program is mentioned at this point since it is similar to the Army's MICROM SERGEANT Depot Program. MORETS employs "road-map" control manual data management concepts developed for the Minuteman WS-133 System in a microfiche storage/retrieval system that provides overhaul technicians with a total, easily accessible maintenance information library.

In the MORETS program, all existing and supplemental data will be referenced in unique Road-Map control "fiche-manuals" that will direct the technician to the appropriate maintenance information for each overhaul function, together with a listing of the required tools and test equipment. A master index will be included that lists overhaul reparables by part number and is cross-referenced to the applicable vendor code number. The Road-Map "fiche-manuals" will contain data status lists for each overhaul repair area that will include:

- Current revision status of all reference data for file control

- Alpha-numeric listings by drawing, technical manual and engineering document number of all reference data

The unique easy-to-use job-oriented Road-Map "fiche-manuals" are the heart of the new microformatted concept, since they integrate and reference the maintenance data required for each overhaul job. These requirements include various contractors' engineering and manufacturing information, vendor drawings, specifications, brochures, existing technical manuals and supplementary documents.

The engineering drawings and other large-size diagrams and schematics will be on 35mm, whereas the standard 8 1/2 x 11-inch technical manual and vendor information, etc. will be on 16mm. A microfilm jacket system, using Boeing's VUCARD microfilm standards (paragraph 4.6.3.1), is being employed, since it is the cheapest and quickest way to microform odd size drawings and technical manual pages that are constantly changing.

The MORETS concept also involves a study of the current engineering drawing/data system (format etc) relative to improving its microfilm and other capabilities for maintenance uses. Finally, the MORET concept involves a new, single-threaded and integrated maintenance information development and application (test/production/training/ customer) approach that weds the new microfilm aspects into a weapon

system total development framework. This latter approach is
necessary in order to have adequate, timely and verified "fiche-manual"
maintenance information available at all points of use!

4.5.3.8	MICROMS Microfiche Field Tests
4.5.3.8.1	Introduction

After experimenting with microfiche formats and viewing equipment,
the Army wanted to see how they worked in the field. The Army knew
that the MICROMS concept would work at the depot level, but didn't know
to what extent microfiche could be used by a regular Army unit. Thus,
the SERGEANT missile system was picked for a field test. It was felt that
the SERGEANT, being neither one of the simplest nor the most complex
Army missile system, would be a representative test vehicle. The tests
were conducted at Fort Sill, Oklahoma and were divided into two distinct
phases. Phase I began in July of 1968 and lasted until the following
October; Phase II took place in February of 1969.

4.5.3.8.2   Test Ground Rules

For the test, personnel were instructed to perform their normal work
activities. The firing platoon was given practice firing missions to carry
out while troubleshooting procedures for actual and simulated problems
were performed. At the same time, the regular preventive maintenance
schedule was carried out. The Direct Support (DS) platoon performed
their normal functions in the shop, the Field Maintenance Test Station
van, and in the technical supply area. Throughout the test, both simulated
and actual problems were assigned to the proper level of repair as stated
in the Maintenance Allocation Chart (MAC). In order to provide an active
comparison between MICROMS and conventional technical manuals, each
of the problems was solved twice -- once using microfiche and once
using manuals. The active maintenance time for a particular problem,
simulated or actual, was defined as the total of preparation time, fault
isolation time, and checkout time. For each operation, time was kept to
the nearest tenth of a man hour.

4.5.3.8.3 Test Objective and Test Results

The test objective was: "to determine the military potential of the MICROMS concept through a comparison of present technical manuals and MICROMS, with special emphasis on adaptability, operability, durability, maintainability, hardcopy printout requirements; and human factors engineering" (Reference 23). The following is a summary of the test results:

Adaptability - The board found that the two-page viewer and copier can be used in the firing platoon headquarters, direct support shop, technical supply office, and field maintenance, without modifications to existing system equipment. The use of either the one-page or the half-page viewer in technical supply is a decided advantage over technical manuals because of volume reduction and ready-reference availability.

Operability - During the portion of the MICROMS test in which technical manuals were used, a number of actual malfunctions occurred. Fifteen were selected as representative. It took an average of 1.8 man-hours active maintenance time to correct each of these failures. It took an average of 1.2 man-hours to correct each of a comparable 15 of these failures using microfiche (in lieu of printed technical manuals).

Durability - No significant degradation of the microfiche material occurred during the test.

Maintainability - Virtually no preventive maintenance, other than the occasional cleaning of screens and lenses was required. It was recommended however, that the complexity of the electrical circuits contained in the two-page copier is such that formal training should be provided technicians responsible for maintenance on those items.

<u>Hardcopy Printout Requirements</u> - The quality of these printouts made
from the microfiche used in Phase II tests was comparable in legibility
to a technical manual. 1308 operations were performed and 71 (5.4%)
required printouts.

<u>Human Factors Engineering</u> - The hand viewer was ruled out because of
its awkwardness and because of its extremely limited field of vision.
After using it, even for short periods of time, operators reported exper-
iencing severe eye fatigue. Also, the hand viewer could not be used
successfully by personnel wearing eyeglasses.

4.5.3.8.4   Concluding Remarks

Reports indicated that the attitude of the men changed radically during
the test. From a considerable measure of hostility at the outset,
occasioned by problems, the attitude changed to a considerable measure
of acceptance and enthusiasm and a desire on the part of the men to
keep the microfiche equipment.

Considering the factors operating against positive test results - the
problems encountered initially with the equipment and the microfiche,
the fact that the fiche were not specially formatted to realize their full
potential, and the fact that the SERGEANT vans were not designed to
accommodate fiche equipment - with these considerations in mind, the
success of the microfiche test was viewed as strongly positive by the
Army (Reference 23). See Figure 4.5.3.8.4 for a summary of
the test conclusions and recommendations.

4.5.4   "Card" Microfiche System

4.5.4.1   General Description

HF Image Systems of Culver City, California, a subsidiary of the Houston
Fearless Corporation, has spearheaded the development of automatic micro-
fiche retrieval systems. The CARD (Compact Automatic Retrieval Display)

TECOM* TEST CONCLUSIONS

1. MICROMS CONCEPT HAS MILITARY POTENTIAL AT ALL MAINTENANCE LEVELS.

2. HAND-HELD VIEWER DESIGN UNACCEPTABLE.

3. VIEWER/COPIER BEST UTILIZED IN SHOP WHERE SPACE LIMITATIONS ARE LESS RESTRICTIVE THAN IN THE VANS.

4. MODIFICATIONS IMPROVED VIEWER/COPIER PRESENTATION AND REDUCED MAINTENANCE.

5. FICHE IN EXISTING TM FORMAT NOT IDEAL. ARRANGING ALL INFORMATION CONCERNING AN ITEM ON ONE FICHE WOULD REDUCE INFORMATION RETRIEVAL TIME.

6. FICHE REDUCE VOLUME OF TECHNICAL LIBRARY.

7. ELECTRICAL CIRCUITS IN VIEWER/COPIER WILL REQUIRE FORMAL TRAINING ON MAINTENANCE

RECOMMENDATIONS FROM TECOM* TEST

1. THAT MICROMS CONCEPT BE USED WITH FUTURE MISSILE SYSTEMS.

2. THAT DESIGN OF HAND-HELD VIEWER BE IMPROVED, OR A SMALL VIEWER BE DEVELOPED TO REPLACE IT.

3. THAT FICHE BE PREPARED IN UNITIZED FORMAT WHEREBY ALL INFORMATION CONCERNING ONE ITEM OF EQUIPMENT IS LOCATED ON ONE FICHE.

4. THAT IMPROVED HAND-HELD VIEWER, OR SMALL VIEWER TO REPLACE IT, BE FURNISHED ARTILLERY BOARD FOR FURTHER TESTING.

* U.S. Army Test and Evaluation Command

(Illustration Source: Reference 23 at end of Document)

FIGURE 4.5.3.8.4.   ARMY MICROFICHE AND EQUIPMENT FIELD TEST

reader is the basic building block in their systems. The standard
CARD reader can function as a low-cost computer terminal or as a stand -
alone storage and display unit. Each reader-display unit has a self-
contained decentralized memory (image bank) that can store over 73,000
pages of information. Other equipment aspects of a complete CARD
system are shown in Figure 4.5.4.1.

The storage medium is NMA or COASTI microfiche, with each microfiche
containing up to 98 8 1/2 x 11-inch pages. Up to 750 microfiche may be
stored in an internal random-access carousel in the reader. The two
unique features of this proven and reliable mechanical retrieval system
are the rotary carousel and the binary coded metalic strip attached to the
top edge of each of the 750 microfiche stored in the carousel. Selection
from the control panel locates the coded microfiche in the carousel file
and withdraws it unto the projection gate. The selected frame is optically
imaged onto the 9 x 12-inch rear-projection screen of the reader.
Total access time is 4 seconds or less. Access to any frame on a given
microfiche is less than one second. In Section 3 of this document, it
was emphasized that automatic roll film retrieval/systems required a
sensing-adjusting system code adjacent to each frame. This cumbersome
disadvantage has been overcome in the CARD microfiche retrieval system.
The reasons are that for a given microfiche, maximum access time is
the farthest x-y position (only 5 1/2-inches on a NMA or COSATI
commercial microfiche), and because indexing is a mechanical function,
similar to spacing on a typewriter. This simple mechanical function,
plus the rapid-access carousel method of retrieving randomly filed
microfiche, have resulted in a fast, reliable and automatic microfiche
retrieval system.

CARD, with its internal binary language, was the first system to put
microfiche on line to a computer. CARD may be interfaced with any
computer or computer peripheral equipment (teletype, dataset, CRT
and etc.) and it may function as an input, output or input/output terminal.

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USE FOR TYPEWRIT MATERIAL ONLY

Magnetic Tape to Microfiche

Original Size
Hard Copy
Reproductions

Micro-Image of Technical
Manual Page

Microfiche Duplicator

CARD Reader-Printer

Reference

Microfiche Camera/Processor

CARD "Finding Clip" Attachment Device

Binary
Code

Reference Copy

Technical
Manual
Paste-up
Pages

Reference

CARD Reader
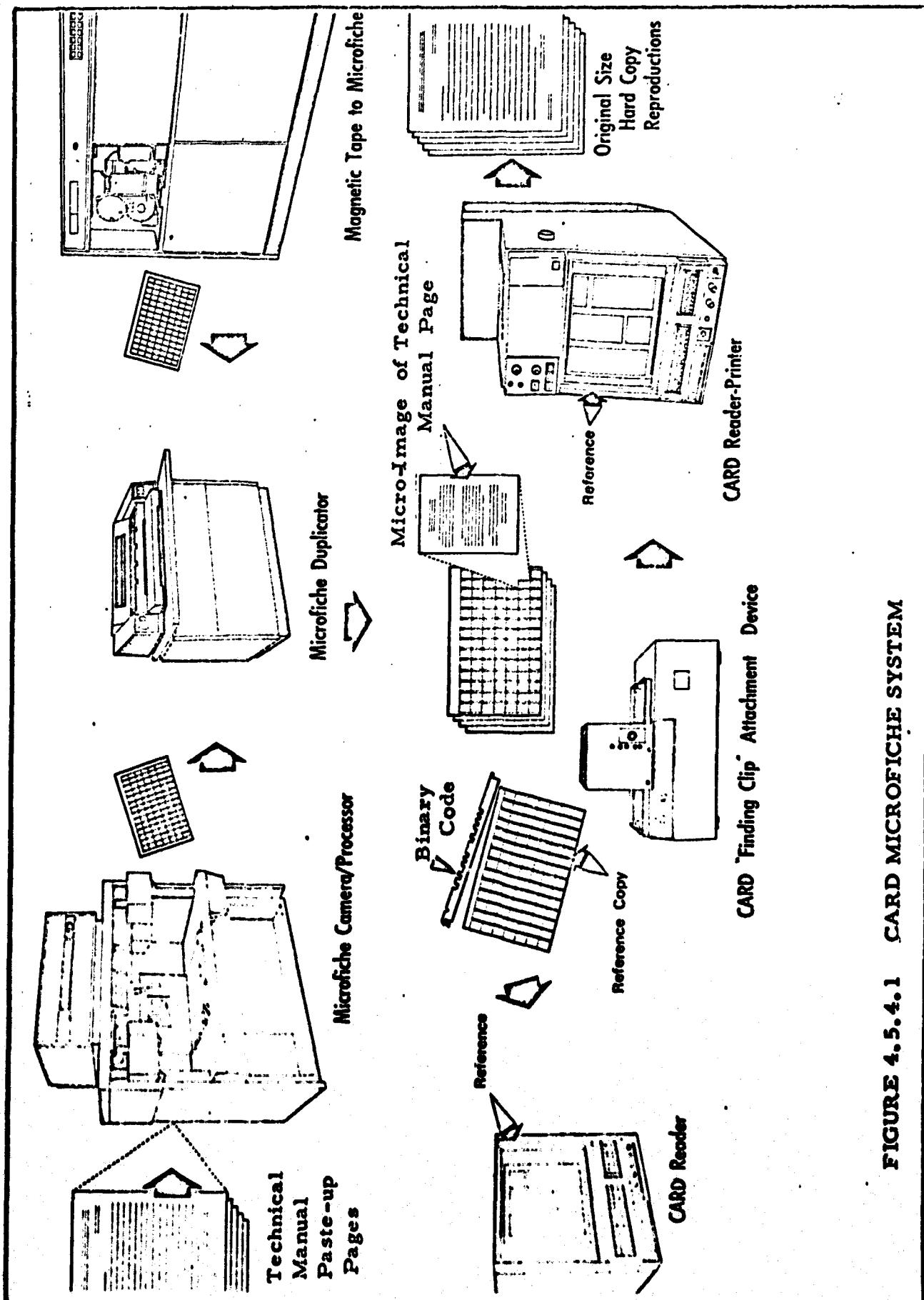
FIGURE 4.5.4.1   CARD MICROFICHE SYSTEM

4.5.2.2   CARD as a Computer Input Terminal

The CARD system can be used to retrieve maintenance information and order spare parts as follows. First, all static data (IPB parts catalog and maintenance information) would be stored and retrieved off line. Once the maintenance technician knew the part at fault, he would use the keyboard for access to the stored maintenance information. In four seconds, he would see an exploded view of the part and other pertinent maintenance (removal, etc) information. The image also contains a coded number (e.g. 5-A), a simple record address, by which the parts storage area computer knows the part. Thus, if he wants to order the part, he would go on-line to the computer. Using the keyboard, he would identify the part number for the computer by pushing buttons 5 and A. He then would push the ORDER button and the part order would be processed automatically. The buttons would remain depressed so that he could verify his order. He also can obtain a hard copy acknowledgement of the transaction from the computer and obtain a printed copy of the data displayed on the screen.

4.5.2.3   CARD as a Computer Output Terminal

When CARD is used as an output terminal, the static technical manual information (stored on microfiche) is computer-controlled. For instance, a CARD unit can store, in one rotary carousel file unit, all of the technical manual pages (over 73,000) required for a given aircraft or missile system for flight line maintenance. Additional carousel files could contain Intermediate Maintenance Level data or any other maintenance information required. This information could be "symptom" programmed, as done in the Navy RAPIDS or WSMAC systems described in Section 3 of this document. Thus, when a failure occurred, a list of symptoms could be fed into the computer. The computer would compare the symptoms with information in its memory and then activates the CARD maintenance information bank to display additional diagnostic information and/or maintenance "fix" procedures for the specific problem involved.

4.5.2.4   CARD as an Off-Line Technical Manual Storage/Retrieval System

The greatest immediate use of the CARD system in maintenance information display applications is expected to be in decentralized operations, according to a recent Aviation Week and Space Technology article (Reference 24). Maintenance technicians, at a maintenance center, can easily access the desired page(s) and then make hard copies for use at the job site. Airlines are presently experimenting with this application, since any one of over 73,000 8 1/2 x 11-inch technical manual pages may be retrieved in 4 seconds or less. An additional carousel file, with 73,000 more pages, can be inserted in the viewer in less than 2 minutes. Thus, all of the black and white or colored technical manual pages required for the maintenance support of the most complex weapon system or equipment can be easily stored in several carousel files.

4.5.2.5   Other CARD Features

The basic CARD viewer is a table top unit, weights 85 pounds (without printer) and uses a quartz-iodine lamp as a light source. The operator can read the displayed information clearly from 25 degrees on either side of the screen's center. The system's resolution permits an operator with 20/20 vision to read 10 point type at up to three times the normal reading distance.

CARD reader-printer models weigh 120 pounds and employ a dry silver process that requires no chemical baths or saturated sponges. They produce original size reproductions up to 11 x 17-inches within 14 seconds. The printer may be programmed to print in multiples (1-11) individual frames, or the automatic sequential printing of all the frames on a given microfiche.

Ease of file updating is a major factor that must be considered in any automatic microfilm system. The 750 individual microfiche in the CARD

rotary carousel provides a convenient and rapid method of loading, storing and updating a 73,000 technical manual page file. Since the file system always returns a previously selected microfiche to the same spot where it was formerly located, updating can be quickly done by simply replacing individual microfiche.

This file arrangement allows the data to be organized for each type of subject matter, so that information can be stored, retrieved, and updated in a logical system, sub-system, etc. manner. For example, technical manual information that is frequently changing can be located in a different file section than static information. Classified information can also be segregated and access controlled via the keyboard. The CARD design simplifies the tasks of initial loading or later updating of the file and prevents handling of the microfiche by the operator. In practice, updated microfiche would be banded together and delivered to each maintenance station viewer. To update the file, the operator would simply open an access panel (that can be locked if file is classified), removes the microfiche containing obsolete information, inserts the new microfiche, and closes (and locks) the panel.

4.5.2.6   CARD System Applications

Several thousand CARD units are being used by airline reservation agents to provide random access to microfilmed reference (schedules, fares, etc.) pages. Airlines are also testing the CARD system at maintenance bases.

Microfiche has many advantages (over other microformats) that must be exploited in future technical manual maintenance information presentation system applications. The CARD system is the best automatic microfiche retrieval system available but certain environmental problems must be solved. The CARD unit is non-militarized and must be used in an office environment. This aspect can be rectified, as was done in the RAPIDS (paragraph 3.4.4.2.2), Army EDS (paragraph 3.4.3.5) and

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and MICROM (paragraph 4.4.1) programs. Other problems, such as the "fault-fix" programming of the technical manual maintenance information, formatting and indexing must also be worked out.

4.5.6   Bell and Howell Microfiche Systems/
                             Equipment

4.5.6.1   General Information

The Micro-Data Division of the Bell and Howell Company has been a leader in the development and production of many different types of microfilm equipment that has been successfully employed in numerous technical manual microfilm programs. Section 5 of this document describes a number of airline microfiche applications and Figure 5.4.2 shows a typical Bell and Howell microfilm jacket system. Air Canada, Delta, Icelandic, Texas International, Pacific Southwest, Air Jamica and other airlines are using Bell and Howell microfiche production and viewing equipment. International Harvester (Impact Program), White and Kenworth Motor Trucks, General Electric, Sikorsky and many other companies are using Bell and Howell microfiche equipment for presenting technical manual information.

4.5.6.2   Portable Microfiche Unit

The Bell and Howell portable microfiche unit, shown in Figure 4.5.6.2 is used by airline, trucking and other industry maintenance technicians in isolated areas away from the main data base. The unit has a 11 x 11-inch viewing screen with a 21:1 reduction ratio. This rugged suitcase unit handles microfiche and jackets up to 6 x 6-inches and weighs 16 pounds. It operates on 117 volts or 12 volts (via automobile cigarette lighter connection). An auxiliary power-pack may also be used. All standard microfiche grid formats are accepted for locating manually (via locator arrow) any page on a fiche. See Appendix in rear of document for additional information on Bell and Howell readers and reader-printers.
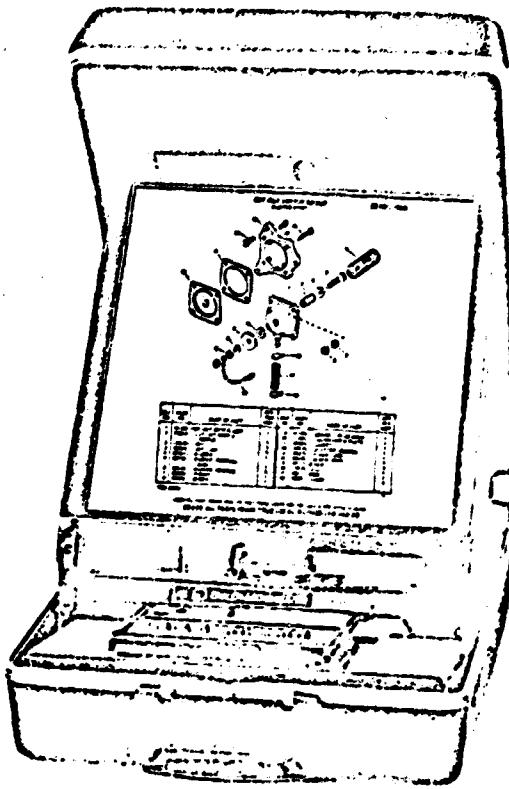
1. **FOCUS:** Focus control is up front for easy adjustment.

2. **ON/OFF SWITCH:** Conveniently located push button.

3. **CARRIER CARD LOCKING:** Just slide carrier to back and right for locking position.

4. **CARD CARRIER OPENING:** Just slide carrier to left side and forward to automatically open card carrier.

5. **LOCATOR ARROW:** Located on card carrier, arrow pinpoints exact page to be viewed.

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL
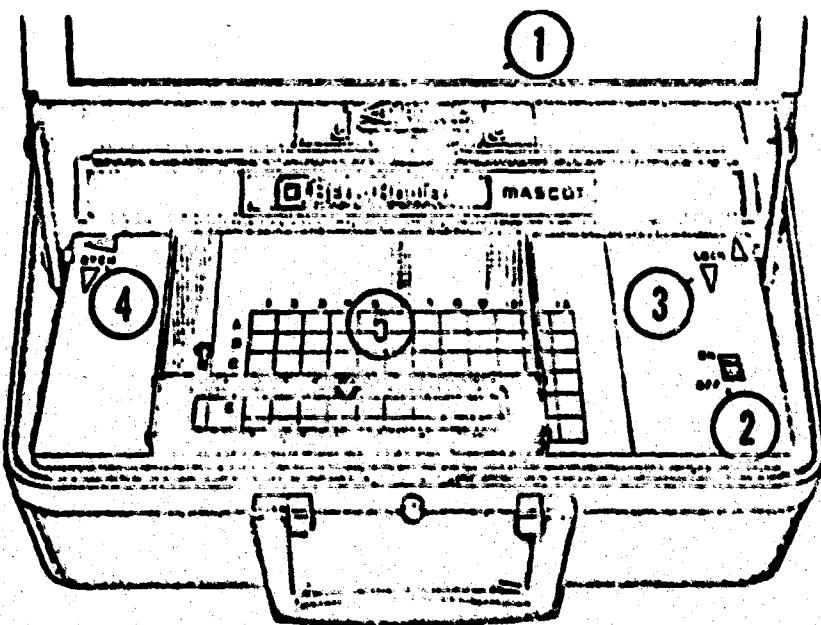
FIGURE 4.5.6.2   PORTABLE MICROFICHE READER

4.5.6.3   Magnetic Microfiche Files

The microfiche "magnetic finder" file trays or tubs, shown in Figure 4.5.6.3, are distributed by Bell and Howell. These trays, used successfully in the Army MICROMS program (paragraph 4.5.3.3) are made in various sizes and hold from 80 to 800 microfiche. The trays are used as follows: When the correct tab designation is selected by the technician and pulled forward, the microfiche film separators magnetically fan or ripple open, providing instant recognition of all the microfiche heading in that tab area. The microfiche heading or "header" provides the technical manual number and title (Appendix A-2) or in some cases, the system/equipment title as shown in Figure 5.4.2.2. A heavy gauge plastic "outguide" is inserted and the microfiche is removed. This "outguide" feature prevents accidental mis-placement of the removed microfiche and assures its return to its proper place in the "magnetic finder". Outguides may be used to mark several microfiche removals. Index guides are made of study aluminum to prevent the microfiche from curling (which may jam the reader). A lock rod holds index guides and separators in position to prevent accidental removal and mixup. The microfiche and their magnetic separators rest on cork pads to prevent damage. The two magnetic trays, shown in the lower illustration of Figure 4.5.6.3, contain 722 microfiche with information on 130,000 White truck parts. This data was previously filed in 52 manuals (over 48,000 pages) requiring 25 feet of shelf space. Bell and Howell also produces microfilm metal cabinets with locks designed for storing 4 x 6 microfiche in large quantities. Individual sections may be segregated and locked for storing classified microfiche.

4.5.7   Norelco Programmed Instruction Microfiche Display Unit

4.5.7.1   Introduction

The Norelco microfiche presentation unit, shown in Figure 4.5.7.1, is being included in this document in order to demonstrate that mechanical programmed instruction (PI) presentation devices do have a role to play in future

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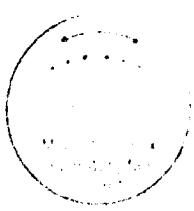
operation-maintenance information presentation systems. This
Norelco PI or programmed learning (PI) unit is typical of many
that are available. Little research has been done relative to
mechanical PI operation-maintenance instruction approaches.
Paragraph 4.2.2.2 describes Boeing's Programmed Maintenance In-
struction (PMI) research efforts.

4.5.7.2   General Description

The Norelco EL 9001 unit illustrated uses 3 x 5-inch microfiche (198 frames
in 22 lines of 9 frames each). The 22 pound unit has a 5 x 8-inch rear
projection screen and magnifies each image 25 times. Linear or extensive
branching programs may be presented (frame selection is via 8 pushbuttons
with forward and reverse). Random access to any of 22 lines of microfiche is
provided by a thumb wheel control. The pushbutton selection system and
manual random access wheel are so designed that a maintenance technician
or flight crew member can easily return to any frame on the microfiche
after a time away from the unit. They also facilitate removal of the fiche.
Any frame can be accessed rapidly from any point in the program.

There is an optional Written Response Unit (shown in Figure 4.5.7.1) for
written responses which contains a paper strip that is advanced by an independ-
ent motor drive in coordination with each maintenance information flight
crew checklist frame on the viewing screen. When the next frame is
selected, the paper written on moves under a transparent window. This
gives the technician or crew member reinforcement by allowing him to
compare his answer with the correct or better response subsequently
projected on the viewing screen. However, it is impossible for him to
change his answer because it is protected by the transparent window and
locked in the unit.

Random Access Wheel

Loading Microfiche

5 x 8-inch Screen

Programmed Learning Unit

Pushbutton Selection System

Written Response Unit

Activated by frame selection
on above PL unit

Writing area - 3 x 1-inch
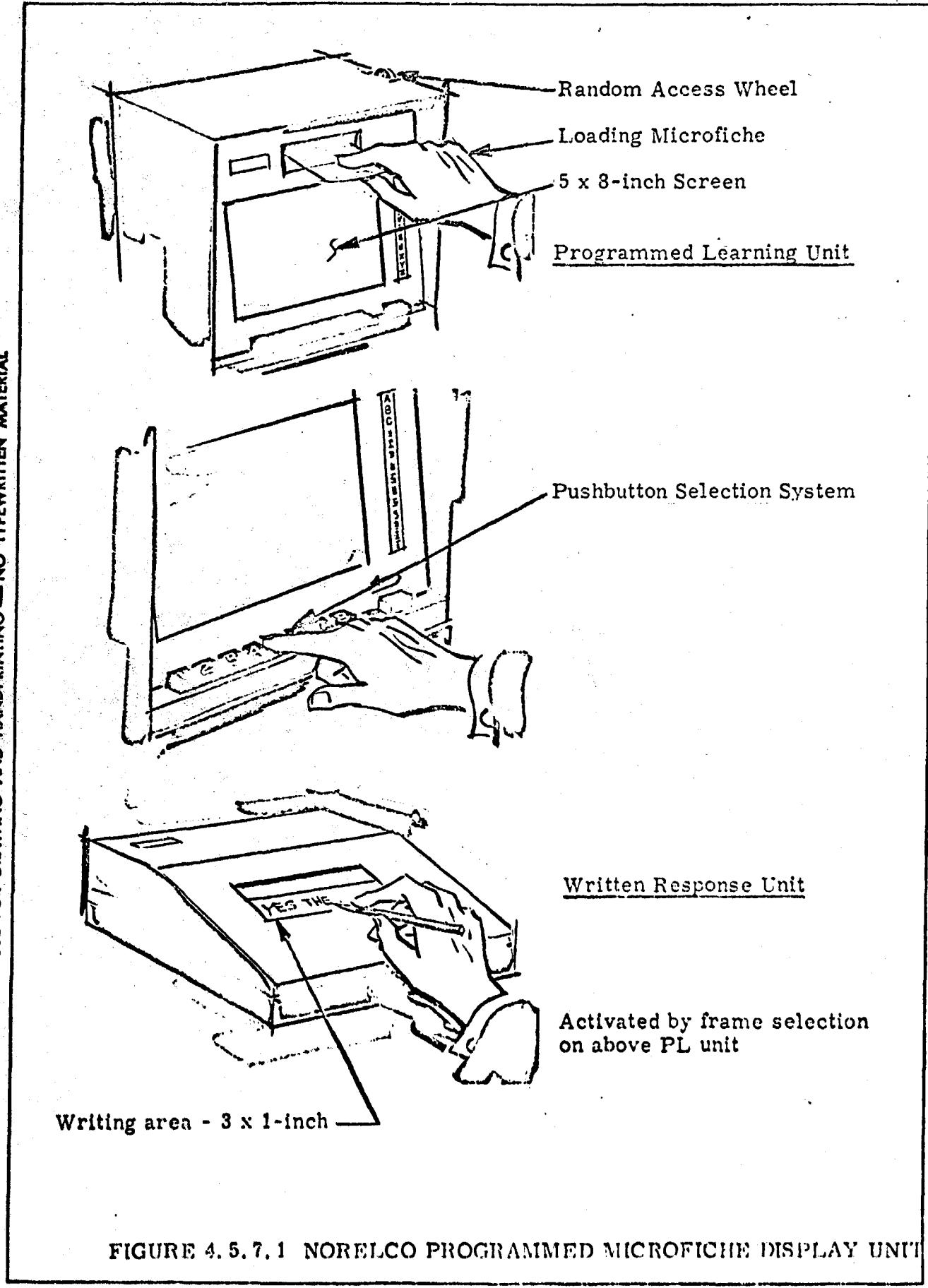
FIGURE 4.5.7.1 NORELCO PROGRAMMED MICROFICHE DISPLAY UNIT

4.5.7.3 Potential PI Operation-Maintenance
Instruction Applications

It is not the intent of this document to deviate from the stated goal of
analyzing technical manual microformat approaches in briefly discussing
programmed instruction applications. For instance, the Norelco programmed
instruction display unit employs microfiche and could be used for presenting
operation and maintenance information as well as individualized training.
Checklists, inspection items, and operation-maintenance information could
be presented and the technician or flight crew member requested to record his
response to each programmed query. If a checklist response was negative
or a fault was detected, his written responses or brief description of switch
positions, indicators, etc. would be used to assist others in rectifying
the system/equipment maintenance problem in question.

These PI units could also be used to train the maintenance technician to
think analytically and how to apply theory (on-the-job) in ways the conven-
tional printed technical manual could never do! Some Aerospace companies
have made use of the mechanical programmed instruction approach in
the supplemental flight and other technical manual areas. Their goal has
been to provide individualized instruction relative to the use of information
contained in the conventional manuals. The mechanic or pilot could also
use the PI unit for review or remedial independent self-instruction purposes.
Portable mechanical P I units have been used in Viet Nam and at other remote
bases to train technicians on-the-job and to explain in detail new complex
technical manual maintenance procedures that were urgently needed on the
field. Both 16mm (Audiscan - paragraph 3.4.7) and microfiche approaches
have been successfully employed.

A perennial problem with technical manual users is keeping up with the
technical changes! In this case, the PI unit could be used for on-the-job
training relative to new operation-maintenance instruction changes being
incorporated in the technical manual microfiche library. The microfiched
technical manual information could be used in these units along with the PI
microfiche.

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These ideas were presented to show a few potential maintenance instruction uses for PI. There are many other operation-maintenance instruction applications that could profitably use the unique, random access, feedback and branching capabilities of Norelco's simple, efficient, cost-effective, reliable and light-weight (approximately 28 pounds for both units) display and feedback PI equipment.

Research in this new mechanized individualized instruction relative to operation-maintenance information has been hindered partly due to the costly mistakes and problems encountered with computerized PI. Research in this area should be accelerated, for the prime advantage of this simple, mechanical, microfiche PI approach is its ability to establish an active learning situation in which the technician is obliged to react to and build upon the knowledge he is acquiring as he is acquiring it. Learning is speeded up by immediate correction, reinforcement or reassurance that a point has been grasped. Each technician is personally involved in a PI program and works at his own pace.

4.6   MICROFILM JACKET SYSTEMS

4.6.1   General Introduction

The last portion of this section deals with three microfilm jacket systems: microfiche, variable unitized card (VUCARD) and Kodak's MICROSTRIP.

4.6.2   Microfiche Jacket Systems

4.6.2.1   Introduction

In the previous microfiche portion, it was stated that basic microfiche systems offered speed, flexibility and economy in handling heavy volumes of complex and changing information. It was also emphasized that the Army found microfiche to be one of the most practical solutions to the multiple problems of technical manual information storage, rapid inexpensive distribution, and most important, availability for quick reference.

A relatively new microfiche adaptation called microfiche jackets which will play a major role in future operation-maintenance information presentation systems is now analyzed. Microfiche jackets have all of the aforementioned microfiche advantages plus the additional advantage of being able to change any image on the microfiche easily and rapidly. This is important in a technical manual program where revisions may be frequent but less than 20 percent of the total page count of a given manual. The jacket format provides for add-ons, deletions, and substitutions of single pages or film strips (series of pages) as required. The microfiche jacket system has two other characteristics that distinguish it for use in technical manual information systems: (1) The emulsion side of the original film is always completely protected while it is in the file and while it is in use, (2) The jacket's built-in paper index can be typed upon, hand-posted, or used with mechanically-prepared labels. Such indexes are available in color with notch codes for easy file classification. This color and notch feature reduces microfiche misfiling, and this increases the integrity of the maintenance information file. Figure 4.6.2.1 cites other microfiche jacket advantages.

4.6.2.2   Jacket Description

The microfiche jacket, a close relation of microfiche, is a means of housing strips of microfilm by trapping them between two panels of Mylar film. Each strip of film rests in what is known as a chamber. It may be considered as a filing card with chambers for inserting 16mm, 35mm, 70mm, or 105mm microfilm images in strips or frames. The jacket, with the film strips in it, can be used directly to create duplicate fiche copies. The relation between the dimensions of the microfilm and the jacket chamber is such that the film always remains fixed in position when the jacket is in use (as when being duplicated in a printing unit) but it can be moved along in the chamber by subsequent film additions for updating the film. Duplicate copies are created by contact printing without problems or loss of quality, because the emulsion side of the film is against the thin side of the jacket. Thus, the jacket is really a file folder, suitable for technical manual page inserts of

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FIGURE 5.6.9.1 MICROPHONE BRACKET ARRANGEMENT

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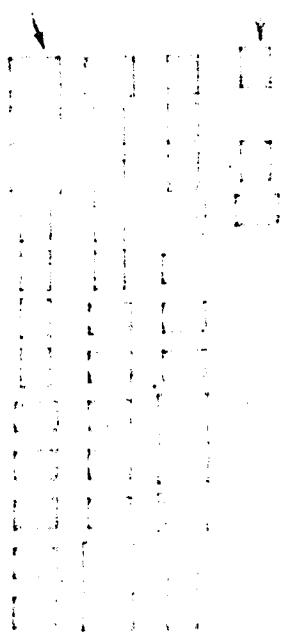
varying sizes, formats, and colors, that permanently protects and permits the rapid reproduction of its indexing and all of its contents.

4.6.2.3   Other Jacket System Equipment

Figure 5.4.2 shows the various equipment components involved in the input/output phases of a typical microfiche jacket system.

4.6.2.3.1

In the input phase, the technical manual paste-up pages are photographed, using rotary or planetary cameras, on 16 or 35mm microfilm. The next input operation requires a jacket reader-filler that accurately and rapidly inserts single or multiple images into the microfilm jacket without the use of tape, adhesive or the operator fingering the microfilm. The header index for each microfiche can be printed, typed, addressographed or stamped on the jacket's built-in contact printable index.

Figure 4.6.2.3 shows a jacket reader-filler produced by Bell and Howell that has these features:

- Files 600 strips of microfilm per hour
- Rapidly updates the Microfiche Jacket file with single or multiple image additions
- Verifies images before insertion into the Microfiche Jacket
- Registers the Jacket in precise relation to the film track for positive and rapid film insertion
- Cuts exactly between images by exposing the knife on the Reader screen
- Cleans the film as it is being filed into the Jacket
- Avoids fingerprints and other film damage
- Automatically cycles through three functions - film cutting - jacket indexing - notch clearing for updating
- Rapidly locates a predetermined Jacket chamber
- Accommodates 100 foot rolls of 16mm microfilm
- Negative or positive image prism available

MICRO
JAGUAR
REVD
PAGE
(DELL - POWELL)

MICROFICHE

- Available in 16 or 35mm models

- 23X magnification/17 x 17-inch viewing screen

Microfiche jackets are rapidly updated with a reader-printer which also, via its viewing screen, assures complete verification of the images (pages) being inserted into the jackets.

4.6.2.3.2

In the output phase of a typical microfiche jacket system (Figure 5.4.2), a printer-processor is used to duplicate the microfiche jackets. The lower illustration in Figure 4.6.2.3 shows rotary printer and rapid processing units that can produce up to 400 low-cost Diazo or Kalvar microfiche duplicates per hour.

4.6.2.4 Kodak "Micro-Thin" Jackets

Figure 4.6.2.4 shows two format types available in the Eastman Kodak's "Micro-Thin" 4 x 6-inch jackets. Kodak claims these jackets are less than one-third the thickness of conventional acetate jackets. Thus, any file capacity if increased by more than 300% when these jackets are used.

The top illustration in Figure 4.6.2.4 shows a 5 channel (16mm microfilm) format that will hold up to 70 technical manual 8 1/2 x 11-inch pages microfilmed at a reduction ratio of 24:1. The lower illustration shows three engineering drawings microfilmed on 35mm to DoD specifications. As many as 36 engineering advance drawing change notices (ADCNs) or other 8 1/2 x 11-inch engineering data/information on 16mm microfilm can be inserted in the lower three channels. Kodak initially developed this engineering drawing - retrieval jacket system for Boeing. Kodak calls this concept KUED (Kodak Unitized Engineering Data). The key achievement of KUED is that it pulls together in one tab-size transparent jacket (6 x 4-inches) both engineering drawings and supplementary information that must go with the drawings, such as specifications, standards and parts lists (Reference 25)

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ENGINEERING DRAWING (35MM)/REVISIONS (16MM) TYPE

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4.6.2.5   Microfiche Jacket Filing

The microfiche jackets can be filed over 100 to a filing inch in special trays (paragraph 4.5.6.3). Thus, one filing inch of standard 4 x 6-inch jacket microfiche can hold over 7000 technical manual pages (8 1/2 x 11-inch). The completed microfiche jackets, like coded aperture cards and other punched or notched cards in large card filing systems, can also be used with automated filing equipment. Highly sophisticated filing systems are now available that combine color-notched microfiche jackets and electro-mechanical filing. In a typical large installation, there could be in excess of a million images (pages) in jackets, any of which may be retrieved in 6-10 seconds.

4.6.2.6   Technical Manual Application

The microfiche jacket concept provides greater technical manual format flexibility than any other microformat, is the easiest and cheapest microform to update (paragraph 4.6.2.1) and employs standard microfiche readers that are less complex, bulky and expensive (than roll film and ultrafiche), and are more suitable for use in compact quarters. Thus, microfiche jackets are very adaptable for technical manual operation-maintenance information programs. Additional application information may be found under the Vucard (jacket) concept (paragraph 4.6.3).

4.6.3   VUCARD System

4.6.3.1   General Description

The Boeing Company is using the VUCARD (Variable Unitized Microdata Card) system for the microfilming of their aircraft engineering drawings and related engineering data. The VUCARD, a 7.375 x 3.250-inch microfilm jacket type card, is shown on Figure 4.6.3. This is the same size as the traditional tab card. The familiarity and widespread use of tab size cards and associated file equipment led to the adaption of the aforementioned dimensions as the engineering drawing microfilm card standard. The film is the base material and the whole of the card is considered appropriate for

VU CARD THICKNESS .0070 ±.0004

7.375 ±.005

HEADER - ONE LINE

VARIABLE
LENGTH TO
FULL CARD WIDTH

3.250
+.007
-.003

VARIABLE NUMBER
TO FULL CARD DENSITY -
BOTH HORIZONTAL & VERTICAL
PAGES 11 X VARIABLE & 8½ X 11

MIXED 35 MM
& 16 MM

Reserved for
Eye-Readable
Material for
Amplifying
Header I. E.
Classifications
& Cross Refer-
ences.

1/16" RESERVED FOR CARD NOTCHING

747/65B80230 SHT 11 REV - ADCN

2 - ROW
35 MM

Note - 35 MM
Individual
Frames or
Continuous
Image for
All Formats.

4 - ROW
16 MM

Note -
Horizontal or
Vertical
8 1/2 x 11-inch
Pages Plus
Continuous
Image of Fold-
Out Pages.

FIGURE 4.6.3   VUCARD TYPICAL FORMATS

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image retention except for the bottom 1/16" which is reserved for possible card notching and automatic sorting use. (Reference 26).

4.6.3.2   747 Aircraft VUCARD Test Program

This system was initially tested using 747 aircraft engineering drawings and is now officially used for all 747 drawings and related data. The drawings and data are copied using 35mm and 16mm cameras respectively. Then, the microfilmed drawings and data are inserted in VUCARD jackets with jacket filler-equipment similar to those shown in Figure 4.6.2.3. The drawing number and additional information is typed for the header, as shown in the sample VUCARDS on Figure 4.6.3. Note that the total area of the drawings are placed on the vucard, preferably as a continuous not a segmented, image when drawings are very long. Also note that the change, or amplifying notations applying to that drawing, is also placed on the same sheet of film, thereby creating a single unitized data package for each drawing sheet.   (Reference 27).

4.6.3.3   San Diego VUCARD Meeting

Representatives from The Boeing Company and 31 other Aerospace companies and military agencies met in San Diego, California in December 1968 and reviewed a draft specification and accord covering this new multi-image, film base, microfilm card. The objectives of this joint meeting were to:

a. Ensure that all companies adopt the same basic parameters regarding card form microfilm to the maximum extent possible.

b. Stimulate an industrial move toward the multi-image, film base, card concept in place of the more limited single-image, paper base, aperture cards, but with a minimum of transitional problems and cost.

c. Take steps to expand governmental regulations and contractual requirements to accept the new microfilm card form in addition to the traditional single frame aperture card.

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d. Encourage the manufacturers of microfilm equipment and supplies
to invest in the development of new filming, viewing, and paper printing,
equipment and materials that can effectively handle both the new film base
card and the traditional paper base aperture card, plus the equipment to
economically produce the new film base card in quantity.

4.6.3.4   Potential Impact of San Diego Meeting

The potential impact resulting from companies adopting the VUCARD or
similar standard could be as follows:

a. Abandonment of the keypunch feature of paper base aperture cards.
b. Restriction to one size of film card for all but compelling exceptions.
c. Investment in film card production equipment.
d. Investment in continuous image filming and continuous sheet
printing equipment for larger drawing industries and others who desire the
capability.
e. A unit cost difference between the film base card and the aperture
card.

The cost of producing these VUCARDS for distribution purposes was
initially approximately seven cents but once the film base card is standardized,
it is expected to be fully competitive with the current five cent cost of
producing duplicate aperture cards.

This meeting did not reach a firm agreement on the VUCARD standard but the
consensus was that a National, standardized engineering microformatted
system would be cost-effective in the long run and will become a reality
within a few years. The paper base, single 35mm frame, aperture card
has long been the standard for handling engineering data because of DoD
endorsement and contractual requirements. This single image (engineering
drawing) coded tab card approach is still a requirement and the coded
(key punched) feature is useful for retrieval and other purposes. However,
this will be changed since the VUCARD and similar engineering drawing/
data microfilm approaches are under study by the military and commercial
groups.

4.6.3.5   San Diego Meeting Impact on Equipment
                 Manufacturers

The objective of the San Diego meeting was to eliminate the currently
unproductive competition between aperture cards and microfiche regarding
size and image area. By abandoning unessential differences such as
keypunch, base material and basic dimensions, it is hoped that the micro-
film industry can focus its developmental attention more narrowly yet
competitively on the following universal types of equipment.

a.   Continuous and Random Image Filming of Original Materials

This includes incremental or successive image addition directly to
reproduction master film cards is also considered a desirable objective
to replace existing strip-up or jacket filling techniques.

b.   Film Card Production for Distribution and File Use

This includes a highly automated, integrated machine to produce at least
1500 cards/hour collated and ready for distribution for a total labor
and material cost per card that is competitive with current paper base
aperture cards. Optical header scan to produce card notching or other
card sort coding should be considered as a desirable and ultimate capability
but not an essential immediate requirement.

c.   Image Retrieval at the Office and Shop Level

This involves the future development of (1) viewers (readers) with full
height 35mm image area with no less than 12 times blow back with at least
one other optional higher magnification, i.e., perhaps 12x, zoom to perhaps
24x or 12x and 24x as discrete choices, (2) projectors to show maximum
film card area on to at least a 3' x 5' desk top or wall screen area, again
with no less than 12x up to whatever higher magnifications prove practical,
(3) inexpensive battery operated hand viewers/projectors ranging from
pocket penlight battery size to auto-alkaline trouble lantern size.

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4.6.3.6 Technical Manual Application (VUCARD)

The VUCARD, or a similar standardized engineering drawing microformatted approach, will have a great impact on future technical manual programs. Our goal should be to design an engineering drawing/data microformat system that will result in the use of much of the microformatted engineering information in the technical manual microformatted program. This "commonality factor" and multi-usage of the same microformatted engineering data in test, production, training, technical manual and other programs is a must! Thus, it is strongly recommended that the "external" engineering deliverables (technical manuals, etc.) be considered in t e design of any "internal" engineering drawing/data microformatted system. A single-threaded, integrated Engineering/Integrated Logistics Support (ILS) microformatted "total" operation-maintenance information presentation system is, for the first time, a possibility due to the advent of today's microfilm systems.

4.6.4 Kodak-Recordak MICROSTRIP System

4.6.4.1 General Description

The MICROSTRIP System is a unique "plastic jacket" system produced by Kodak-Recordax and used in the commercial world. A 16mm film strip is contained in one-piece plastic film holders or jackets, as shown in Figure 4.6.4. Five seconds is the average time-lapse between receiving and answering information requests with this system. The key to the simple system is the MICROSTRIP holder, a rigid plastic "wand" which holds a strip of 16mm microfilm images (12-inches long). The end-tab of the holder is color-coded by file category, and is "from-to" indexed by content. Each individual image is also indexed by "tell-tale" targeting. A technician, seated at a MICROSTRIP reference station, could obtain maintenance information from thousands of technical manual pages. The following steps, that are also shown in the top illustration of Figure 4.6.4, would take him from question to answer:

● Identify and withdraw the precisely indexed MICROSTRIP holder from its access file.

Operation: by its color coding. Select the desired MICROSTRIP Holder by its color tab index With the Holder in an upright position.

of the MICROSTRIP Reader. Slide index locator pointer to the "left tab" index marking for desired usage.

MICROSTRIP FILM HOLDER

(Contains 12-inches of 16mm microfilm)
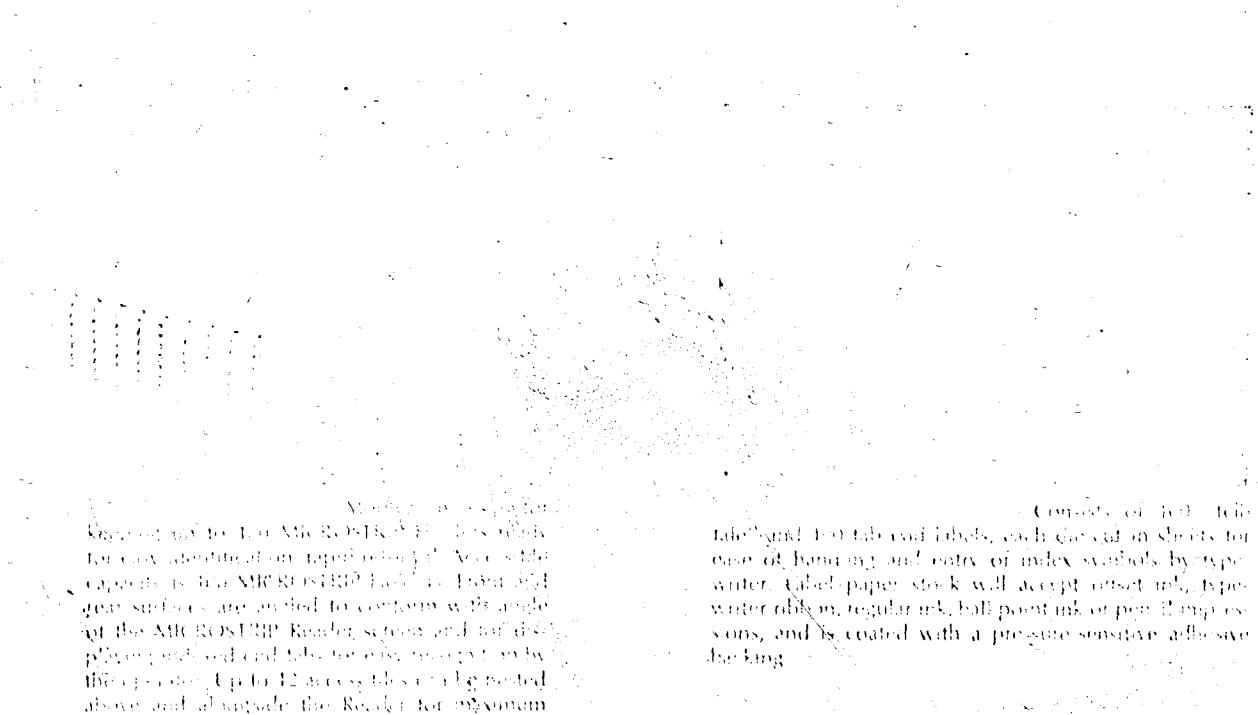
Refer to the MICROSTRIP Holder which for easy identification tape coding. Across the capacity is in a MICROSTRIP Holder is 12in and gear surfaces are applied to conform with angle of the MICROSTRIP Reader screen and for easy positioning and end tabs are also marked by the manufacturer. Up to 12 accessories easily nested above and alongside the Reader for maximum accessories station capacity.

Consists of left tab labels and tab end labels, each die cut in sheets for ease of handling and entry of index symbols by typewriter. Label paper stock will accept onset ink, typewriter ribbon, regular ink, ball point ink or pen stamp versions, and is coated with a pressure sensitive adhesive backing.

FIGURE 4.6.4.1 — KODAK'S MICROSTRIP SYSTEM

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- Drop it into the MICROSTRIP reader slot (in the reader).

- Move the index selector pointer to the image "tell-tale" and image is displayed on a 14 x 14-inch screen.

Simplicity is the outstanding feature of this system. Figure 4.6.4 provides information relative to an indexing kit which is used with the MICROSTRIP plastic film holder. At the end of each holder, an end-tab is provided for color code identification of file category and "from-to" index of content. The top surface of the holder provides for "tell-tale" indexing of each individual image.

The modular microstrip access file is also shown on Figure 4.6.4. Each access file holds 100 plastic 16mm film holders. Each 12-inch film in the holder contains up to 21 images (reduced 8 1/2 x 11-inch technical manual pages). Thus, each access file can hold up to 2100 images (pages). Twelve access files can be located adjacent to each reader or reader-printer providing easy access to up to 25,200 technical manual (8 1/2 x 11-inch) pages.

Additional MICROSTRIP features are as follows:

- Updating of central reference files is easy to accomplish. Basic file components, of a foot or less of 16mm microfilm, simplify replacements, add-ons and deletions.

- Film strips for holders can be produced by standard 16mm micro-filming equipment, without special accessories or attachments.

- Alphabetic or numeric indexing of MICROSTRIP holder end-tabs, and of "tell-tale" index strips, can be accomplished manually, by typewriter, or electronically by computer programming.

- An easily-installed, easy-to-operate reader-printer may be substituted for the reader for installations requiring facsimile prints to be produced from microfilm images.

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USE FOR TYPEWRITING MATERIAL ONLY

4.6.4.2   Technical Manual Application (MICROSTRIP)

This system could be employed in research and development programs or
any programs that require a rapidly changing operation-maintenance
information system. New film strips could be produced daily, or as required,
using conventional microfilm equipment. The approach is also suited to
a task-oriented information system since most single maintenance tasks
could be easily contained on one holder (21 pages) or at the most on 2 or 3
holders. This is a low cost reliable system that is easy to index and
has been proven in hundreds of commercial applications. It's also a low
cost approach for color applications, since the selected portions requiring
color could be easily segreated and placed in separate holders. Classified
pages could also be easily segregated with this system.

Another application could be to small growing systems. As the system
expanded, the MICROSTRIP system could be easily enlarged, since access
file components are modular in design and stack easily for adding new file
increments. Thus, additional access files, each housing 100 MICROSTRIP
holders, can be arranged within easy reach of a seated operator to provide
access to a very large technical manual system.

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5.0   AIRLINE TECHNICAL MANUAL MICROFILM
APPLICATIONS

5.1   INTRODUCTION

This section provides background information on the airlines' maintenance
technical manual approach. Also, a number of typical airline technical
manual microfilm applications that have provided a partial solution to
the maintenance information bulk problem are described. These successful
airline applications employed both roll film and microfiche concepts. This
information was derived from material procured from the airlines, Bell
and Howell and the 3-M and other microfilm equipment manufacturers.

The airlines have conducted numerous evaluations of their maintenance
information bulk problem. For instance, American Airlines, prior to
inaugurating their microfilm technical manual system, required bookcase
space for 11,400 maintenance, illustrated parts, and electrical wiring
technical manuals. These, placed in linear measurement, made a lineup
of books 2850 feet long (Reference 3). Figure 5.1 cites other printed
technical manual problems encountered by the airlines.

5.2   AIRLINE PRINTED TECHNICAL MANUAL
BACKGROUND INFORMATION

5.2.1   GENERAL

The following general background information on airline technical manual
requirements is provided in order to better assess the airline maintenance
information microformat applications described in this section, and their
relationship to the military technical manual microformat applications
discussed in Sections 3, 4 and 6.

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VOLUME OF PAPER

● Manuals Used At A Base — Would outline a football field.

● File Locations — Manual files at 250 locations around the world (PA)

● Paper Manual Costs — $399,000 a year (at $200 a manual) (PA)

● Printing Costs — Over $100,000 per year

● Filing Changes — 26,000 manhours per year

● Missing Pages — Removed for reference and seldom replaced

● Replacement Manuals — Obsolete and missing pages; easier to replace entire manual

● Size of Changes — For one year, weighed over 100,000 pounds and would stack half a mile high (PA)

● Spare Pages — Six million spare pages required yearly to replace lost and mutilated pages (1500 square foot file) (PA)

● Spare Page Requirements — 3,000,000 spare pages must be maintained to support manual and page replacements

● Timely Release of Changes — Average of 3 to 6 months for a revision from conception to release

● Changes — Required 2 to 3 weeks for printing, distributing and filing paper manual changes (PA)

TECHNICAL MANUAL FILE INTEGRITY

● Federal Air Regulations — Govern airlines in all phases including technical manual requirements

● Write-ins — Forbidden by FAR because of no control

● Audits — Periodic audits of manuals required to assure currency by airline and FAA

USAGE FACTOR

● 1,026,000 Consultations Per Year

NOTE: (PA) after an item indicates that this is a Pan American World Airways item. See Reference 28 at end of document for source of information. All other items relate to American Airlines (See Reference 29 at end of document).

FIGURE 5.1   AIRLINE PRINTED TECHNICAL MANUAL PROBLEMS

The size, content, and revision activity of the maintenance information required for a given aircraft type varies widely between airlines due to different aircraft configurations, local engineering changes and the manner in which the publications are handled internally. Some carriers combine the structural repair manual with the maintenance manual and others keep the power plant section of the maintenance manual in a separate engine manual.

5.2.2   ATA SPECIFICATION 100

The aircraft-engine manuals supplied to the airlines by the manufacturers, such as Boeing and Pratt and Whitney, are written in accordance with Air Transport Association (ATA) specifications. ATA specification 100 establishes the format and other standards for the presentation of technical manual information by an aircraft, aircraft accessory or component manufacturer. The specification covers the format, type size and style, indexing, method of presentation, arrangement of material, numbering system, and standards of issuance and revision service.

5.2.3   ARRANGEMENT OF SUBJECT MATTER

5.2.3.1

ATA specification 100 technical manuals have a standardized arrangement of their contents. This identical content arrangement, numbering and indexing system requirement is imposed on the manufacturers who produce the technical manuals. Thus, Chapter 21-00-1 in any airline maintenance manual will cover "Air Conditioning -- Description and Operation."

5.2.3.2

Each page in an Illustrated Parts Catalog (IPC) is identified with a three-part number, known as chapter, subject and figure number, and expressed with three groups of two digits each. Page numbers are used in IPCs beginning with page 1 for each change in figure number. Each page in a Maintenance Manual is identified in the same manner, except that the three parts of the number are known as chapter, section and subject.

A typical maintenance page number would be interpreted as follows:

Detection, Subsystem (Section)

Fire Protection
System (Chapter) → 26-10-1 ← Engine Fire
Code 2 Detector, Unit
Page 102 (Subject)

Second page of
Engine Fire
Detector Unit
Troubleshooting

Configuration
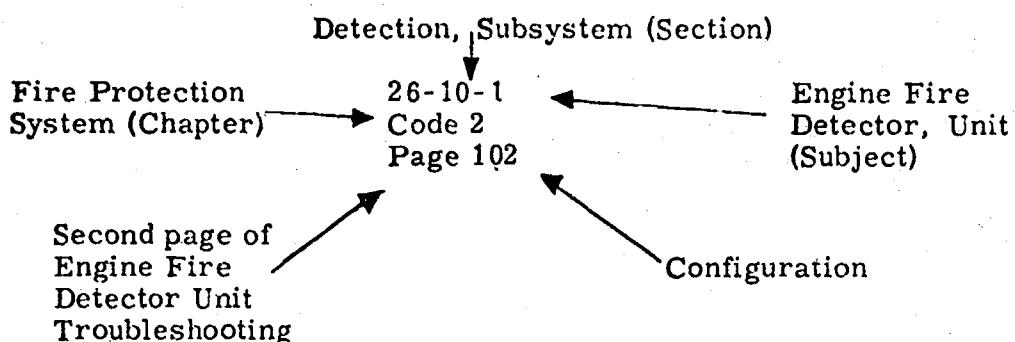
5.2.3.3

All system/subsystem/unit (chapter/section/subject) maintenance data is separated into specific types of information. Blocks of sequential page numbers are used as follows:

Pages 1 through 100	Description and Operation
Pages 101 through 200	Troubleshooting
Pages 201 through 300	Maintenance Practices

Relatively simple units may not require description and operation and/or troubleshooting information. In such cases, unused page-number blocks are omitted. For those items requiring many types of maintenance practices, page block 201 through 300 is omitted, and page numbering and maintenance practices are as follows:

Pages 301 through 400	Servicing
Pages 401 through 500	Removal/Installation
Pages 501 through 600	Adjustment/Test
Pages 601 through 700	Inspection/Check
Pages 701 through 800	Cleaning/Painting
Pages 801 through 900	Approved Repairs

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5.2.3.4

This ATA standardized arrangement of subject matter is emphasized since it is the basis for an indexing/retrieval system that is universally recognized by airline personnel. The lack of a good indexing system and the lack of a standardized numerical arrangement of subject matter in military technical manuals has been a deterrent to the rapid retrieval of the microformatted technical manual maintenance information in the Navy NARF-JAX test program (A-4, A-5 and A-7 aircraft) and other microfilm programs described in Section 6 of this document.

5.2.4   TECHNICAL MANUAL TYPES

ATA specification 100 is applicable to Maintenance Manuals, Illustrated Parts Catalogs, Wiring Diagrams, Structural Repair Manuals, Overhaul Manuals, Tool and Equipment Lists, Weight and Balance Manuals and Service Bulletins. The above maintenance information is suitable for microfilming except as follows:

a.   The Wiring Diagram manuals have presented a microfilm problem due to the fact that approximately 20% of each manual consists of 11" x 17" diagrams.

b.   The overhaul, tool and equipment lists, weight and balance and service bulletins have not been put on microfilm due to either limited distribution, low volume or restricted usage.

5.2.5   TECHNICAL MANUAL SIZE AND CHANGE ACTIVITY

5.2.5.1

The size of the original manuals and change activity varies with aircraft age and the requirements of the carrier. Original Maintenance Manuals vary in size from 5,000 to 8,000 pages and changes range from 100% to 400% per year. Illustrated Parts Catalogs range from 2,500 to 6,500 pages and revisions range from 50% to 300% per year. The Wiring Diagrams average about 1,000 pages for each model type and changes vary from 10% to 100%.

Each carrier negotiates with the manufacturer relative to the number
of technical manual sets needed. This quantity may range up to 100 sets
of manuals. Based on 100 sets, the carrier may be responsible for
handling from 500,000 to 800,000 technical manual pages for one type
of aircraft. When this is multiplied by 3 or 4 types of aircraft, the
volume of maintenance manual pages handled for one issue by one
carrier may be over 3,000,000 pages.

5.3   AIRLINE MICROFILM APPLICATIONS

5.3.1

Most of the commercial airlines, including Western, Ozark, Sabena, JAL,
Lufthansa, BEA and National, have or are in the process of converting
their bulky maintenance technical manual libraries into compact microfilm
systems that employ reader-printers. United, Eastern, American, Pan-
American and others have implemented cartridge type roll films systems.
Air Canada, Delta, Icelandic, Canadian-Pacific, Air Jamaica, Texas
International and other airlines have chosen microfiche as the most efficient
and economical method or system for microfilming their printed technical
manuals. The merits of these two microfilm concepts were discussed in
Sections 3 and 4 of this document and are summarized in paragraphs 5.6.2
and 5.6.3. These microformatted technical manual programs cover
primarily the ATA 100 maintenance manuals and illustrated parts catalogs
(References 28 through 31).

5.3.2

Figure 5.3.2 extracted from the 3 February 1967 issue of the American
Airlines "Maintenance Newsletter", represents a typical microfilm
maintenance information center in operation. The 16mm reader-printer shown
is a 3-M Filmac 400C. Reader-printers with a complete cartridge file are
also mounted on rolling stands which are easily moved to any location in the
vicinity of the aircraft. Table top readers are also employed by the
airlines since, in many maintenance areas it is not necessary to have the
printout capability of the reader-printer. In low maintenance manual usage
areas, portable readers are employed. The portables (microfiche or roll)
weight about 20 lbs and can be easily carried to off-line stations, the flight line
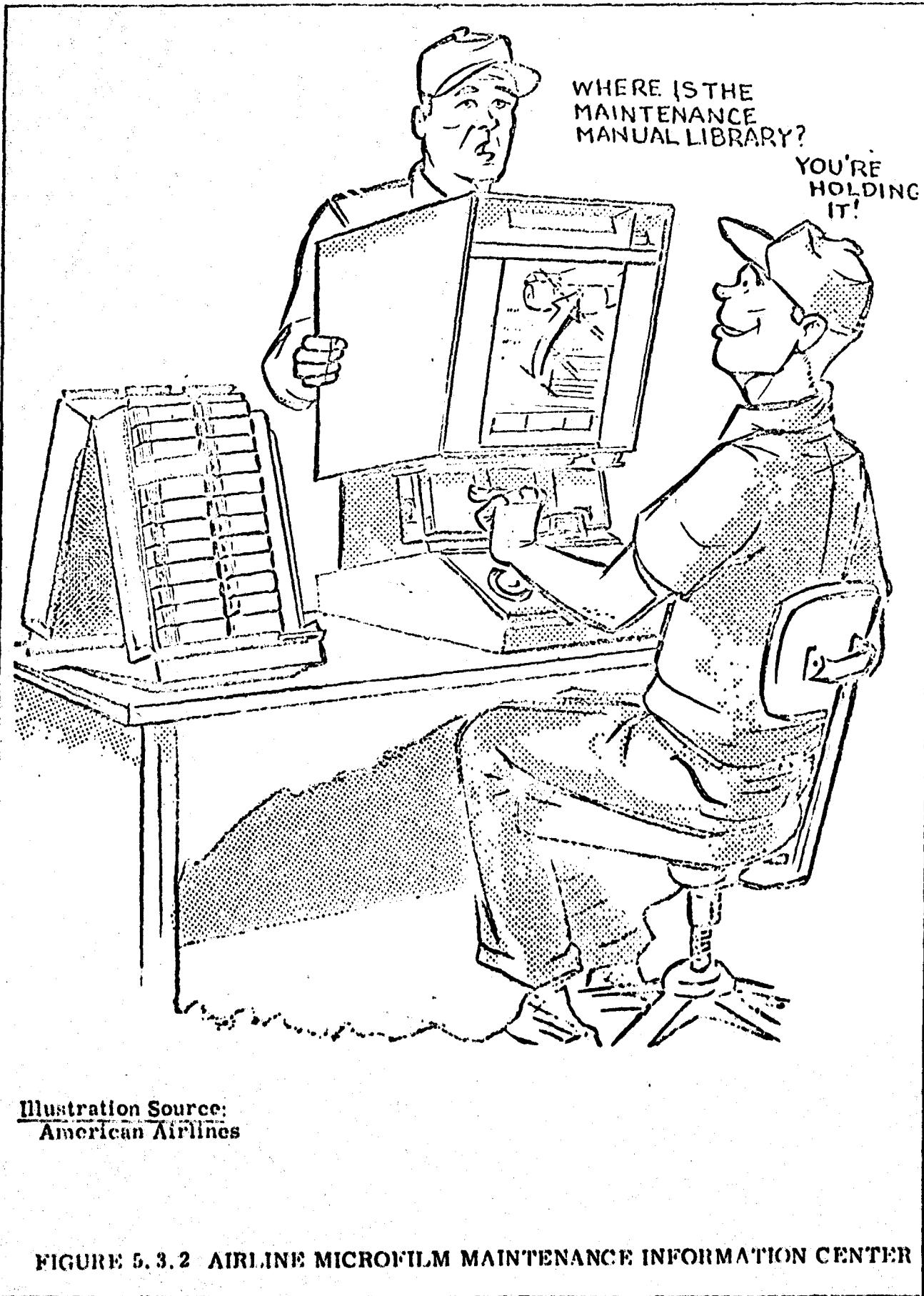
Illustration Source:
American Airlines

FIGURE 5.3.2 AIRLINE MICROFILM MAINTENANCE INFORMATION CENTER

or to other locations inside the airplane or maintenance truck where its use is desired. The portable units operate on regular 115 V 60 Hz aboard the airplane. Other portable models are powered by internal battery (rechargeable) or 12 Volt DC current (automotive). See Sections 3 and 4 of this document for additional information on reader-printer and printer types.

5.4   TYPICAL AIRLINE TECHNICAL MANUAL MICROFILM SYSTEMS

5.4.1   ROLL FILM SYSTEM

Figure 5.4.1 flow chart shows the steps and processes involved in a typical airline 16mm microfilm system. The following description of the process was extracted from information provided by the 3-M Company:

a.   MASTER FILE - The original material is already in use and consists of the following data:

B-720	Maintenance Manual	8,000 (pages)
	Illustrated Parts Catalog	6,200 "
	Wiring Diagram	1,000 "
B-727	Maintenance Manual	6,400 "
	Illustrated Parts Catalog	6,500 "
	Wiring Diagram	1,000 "
DC-9	Maintenance Manual	5,500 "
	Illustrated Parts Catalog	6,000 "
	Wiring Diagram	1,000 "

b.   MICROFILMING - Periodically the entire updated master publication is filmed on 16mm film at a reduction ratio of 24:1. This filming allows placement of approximately 2,200 8 1/2" x 11" images per roll. This estimate allows adequate spacing between chapters to allow for chapter expansions due to revisions. Based upon 2,200 images per roll, the total film library at any one location of this typical airline application consists of the following:

B-720	Maintenance Manual	4 Rolls (Cartridges)
	Illustrated Parts Catalog	3 " "
	Wiring Diagram	1 " "
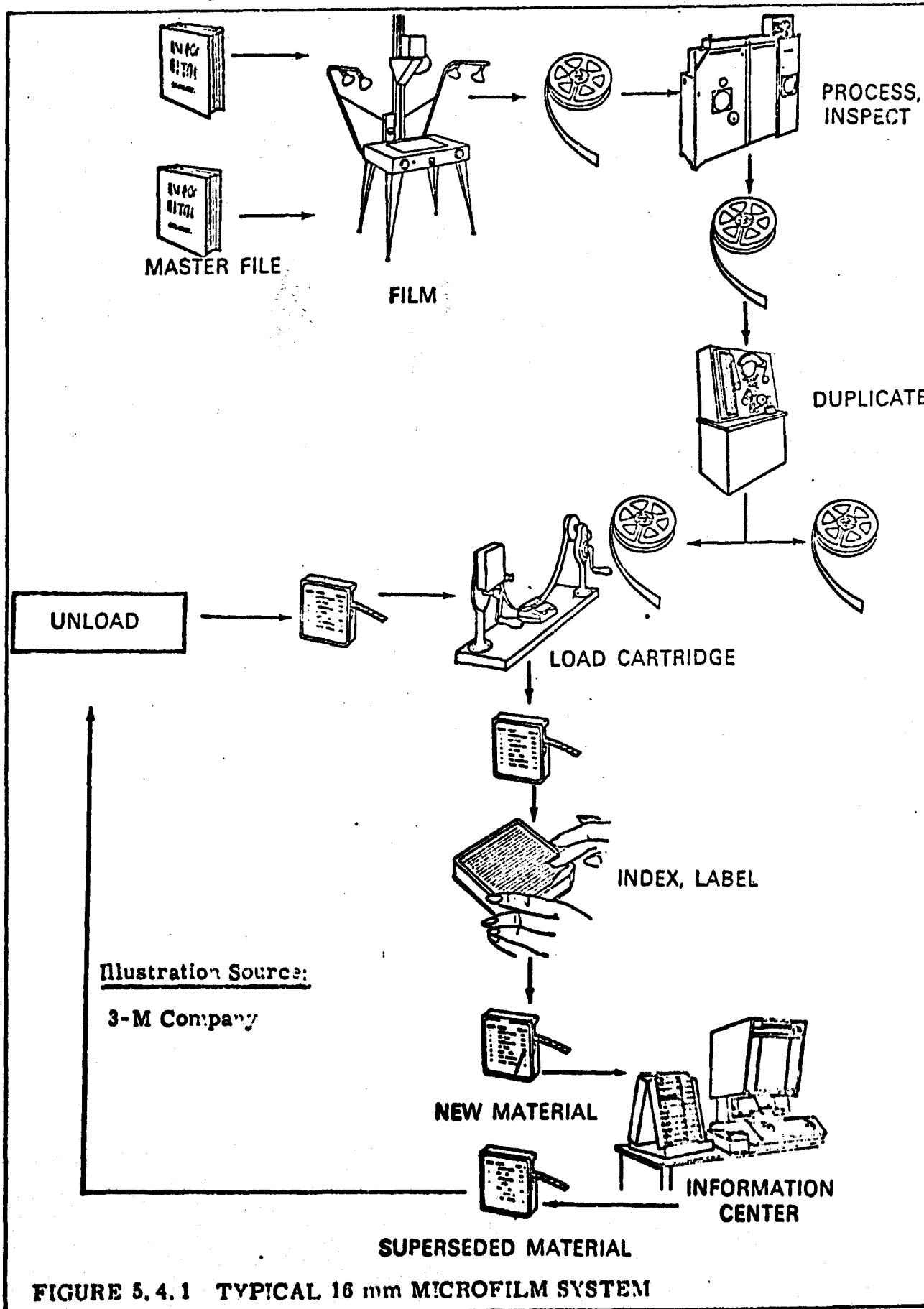
FIGURE 5.4.1 TYPICAL 16 mm MICROFILM SYSTEM

B-727	Maintenance Manual	3 Rolls (Cartridges)
	Illustrated Parts Catalog	3 " "
	Wiring Diagram	1 " "
DC-9	Maintenance Manual	3 " "
	Illustrated Parts Catalog	3 " "
	Wiring Diagram	1 " "

The Maintenance Manuals and Wiring Diagrams will be refilmed every 30 days and the Illustrated Parts Catalogs will be refilmed every 90 days. This refilming frequency is based upon the incidence of revision to the master manual and may be changed if required. Other airline experience has indicated that these frequencies are desirable -- considering both economical and operational aspects.

c. PROCESSING AND INSPECTION - After filming, the exposed film is placed in a processor where it is developed. After the film is developed, standard quality control tests are applied. These include checks for visual defects, resolution and density. As the usefulness of the file depends directly upon the quality of the film, rigid standards are imposed on film production.

d. DUPLICATION - The master negative film from the camera is then placed in a roll-to-roll printer where the required number of issue copies are duplicated. An average of 55 copies of each roll will be distributed.

e. CARTRIDGE LOADING - The required number of issue rolls are loaded into the microfilm cartridges. These cartridges protect the film during handling, and automate film handling and speed retrieval.

f. INDEXING AND LABELING - After cartridge loading, two labels are affixed to the cartridge as follows:

Cartridge Top --->

**B-727 MAINTENANCE MANUAL
CHAPTERS 21 through 27**

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Cartridge Face	CHAPTER	SUBJECT	POSITION
	21	Airconditioning	0010
	22	Autopilot	0060
	23	Communications	0230
	24	A/C Power System	0570
	25	Equip. and Furn.	0980
	26	Fire Protection	1100
	27	Flight Control	1430

The "position" number noted on the cartridge label indicates the odometer reading on the 3-M Filmac 400C Reader-Printer where the noted chapter can be located within the cartridge.

g. DISTRIBUTION - The file ready cartridges are placed in a pre-addressed container for distribution. Upon receipt of the new film cartridge, the addressee removes the superseded film cartridges and returns them. The old film is discarded and the cartridges reused and configuration records are updated.

h. POINT OF USE - The cartridge containing the required subject matter is inserted in the Reader-Printer and the desired page viewed or copied as necessary. A dry copy may be obtained in 6 seconds by depressing the "Print" button. Emergency revisions are located in a small 3-ring binder adjacent to the Reader-Printer.

5.4.2   MICROFICHE AND MICROFILM JACKET SYSTEMS
5.4.2.1   GENERAL

Figure 5.4.2 flow chart shows the steps and processes involved in a typical technical manual microfilm jacket application. A typical airline microfiche development process would be similar to that shown except that different camera types would be employed and reader-fillers would not be required. Airlines like Air Canada, Delta and Texas International who are employing technical manual microfiche systems do their own indexing and layout. Most of the airlines' microfiche applications use the 98 page format.

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INPUT...

Illustration Source:

Micro Data Division,
Bell & Howell

Tech Manual
Paste-up Pages

Rotary or Planetary Camera

- - - -► Broken Line
Represents
"Add On or Updating"
Document Flow

Microfilm
16mm or 35mm

Reader-Filler 1200

Microfiche Jacket

For Updating

File

OUTPUT...

Microfiche Jacket

File

Returned
To File

USE of Jacket for Direct Reading or Hard-Copy Reproduction

Returned
To File

Microfiche Jacket

Printer-Processor 404

Low Cost
Duplicate

Reader,
Reader Printer
or Satellite Files

Figure 5.4.2 TYPICAL MICROFILM JACKET SYSTEM

5.4.2.2 . MICROFICHE FORMAT

Figure 5.4.2.2 shows one type of microfiche format being used by the airlines. The following is a brief description of this particular format:

a. Rows are identified in alphabetical order: A, B, C, D, E, F, G, beginning with A at the bottom of the card.

b. Columns are numbered 1 through 14, beginning at the left.

c. Individual frames (pages) are identified by row and column number, D-10, F-7, etc.

d. · Each card has a heading. The heading gives the manual user as much information as possible to aid him in making the correct card selection quickly without referring to any other source of direction. Beginning at the left, the heading consists of:

    1. The name of the manual.

    2. Titles of card contents.

    3. Card number consisting of chapter (system) number and a numerical sequence number. Also a revision date.

e. The A-1 position of each card provides a complete index of that card, showing the location of each subject on the card. Adjacent images in row A are used for the card index as required.

f. The first card of each chapter has an index of the whole chapter (if more than one card is required for the chapter). It starts with frame A-1 and follows to completion.

The following is a brief description of the file and revision page system used:

a. The microfiche (film cards) are filed in numerical order by chapter number. Each heading is in full view.

b. One List of Effective Cards is included in the Introduction Chapter of each manual.

c. Pages affected by a temporary or supplementary page are boldly identified:

    See Change Page ⟹
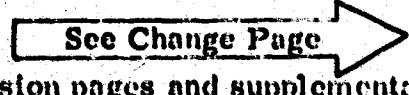
d. Temporary Revision pages and supplementary pages are boldly identified:

    ⟸ This Page Changes Page at Left
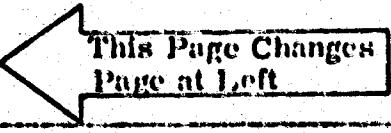
Illustration Source:

Texas International Airlines

DC-9 Maintenance | AIR CONDITIONING-CABIN COMP CONT, CABIN COMP ELEC CONT SYS, CABIN COMP OVERHEAT SYS CABIN RPM IND SYS, FLT COMPT AIR TEMP | 21-3 | 7-15-9
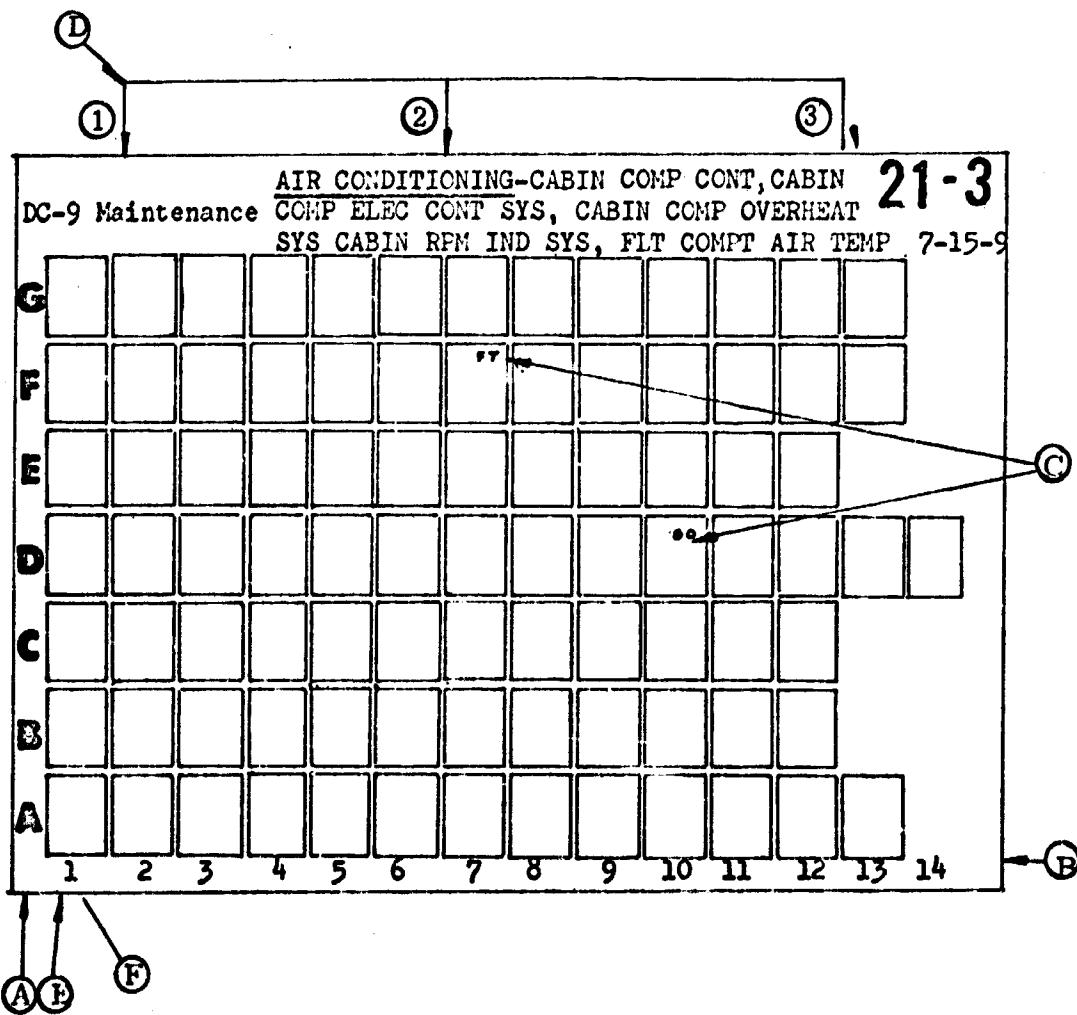
NOTE: The circled numbers and letters shown above relate to sub-paragraphs of the description paragraph (5.4.2.2) of this microfiche format.

Figure 5.4.2.2   AIRLINE MICROFICHE FORMAT (TYPICAL)

5.5   ADVANTAGES OF AIRLINE TECHNICAL MANUAL MICROFILM SYSTEMS

The airline technical manual expenditures discussed in the following paragraphs are those incurred <u>after</u> the development of the technical manual paste-up page by the manufacturer. These analyses compare the cost of keeping printed technical manual information current at the point of use with microformatted technical manual systems. These variable expenditures relate to storage, updating, distribution, and usage (retrieval time) factors and the integrity of the filed information. Some factors, such as file control and integrity, that are an integral part of a good microfilm system, are not easily measurable in economic values. However, no one questions the great advantages inherent in a system that guarantees complete and timely maintenance information at the point of use. The following information obtained from The 3-M Company was derived from different airline technical manual microfilm system cost analyses, and specifically relates to the aforementioned factors:

5.5.1   FILE MAINTENANCE

One accepted cost figure for labor covering the insertion and deletion of technical manual revisions is approximately $30 per thousand pages. This figure has been determined by detailed time studies of mechanics, inspectors, leads, and clerks during task performance. Basic to the cost is the rate of filing which runs between 120 and 150 pages per hour and can be calculated as follows:

To file 1,000 pages at   120/hr = 8.3 hr x $3.90/hr (Salary) = $32.90/M

                               150/hr = 6.6 hr x $3.90/hr (Salary) = $25.74/M

The 120-150 per hour rate varies depending upon the nature of the manual revision and the diligence of the reviser. Elimination of this filing cost is a major expense reduction item. Two large domestic airlines estimated that they saved over 25,000 man-hours per year in filing costs after they introduced microformatted technical manual systems.

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5.5.2 PRINTING COSTS

Printing costs between carriers vary widely depending upon the amount of locally generated revisions, distribution requirements and usage without reprinting---of the manufacturer's supplied revisions. Costs per page range from $.0089 to $.021, according to a 3-M study released two years ago.

5.5.3 USAGE BY MAINTENANCE PERSONNEL

The following quotation given in support of microfilm maintenance information systems by an airline maintenance executive is cited in the 3-M study.

> "The manhours required by mechanics, inspectors, and fore-men to obtain information from the printed technical manuals are substantially reduced. These individuals can obtain immediate prints of the required maintenance information for use at the aircraft. This material is available and current and can be discarded when the job is completed. This eliminates the need for taking notes, removing pages and then having to refile them, removing the manual and having to return it, or making numerous trips between the work position and the manual location to check on procedures and other information.

> "It is estimated that each mechanic or inspector consults a manual twice daily and that a lead consults a manual four times each day. The following table constructs the number of consultations per year using a factor of .7 to compensate for days off the job due to vacation, holidays, weekends, etc.

1900 Mechanics & Inspectors x .7 x 2 x 360 = 813,600
 210 Leads   x .7 x 4 x 360 = 212,400

    Total Annual Consultations   = 1,026,000

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"It is expected that the initial "look-up" time under the microfilm system will be shorter than the 6 minutes now required for an individual to go from the aircraft or work position and find the desired material.

"Four times out of ten the mechanic or inspector must do more than look up the information. In these cases, he must have the information at his work location. The methods now employed, such as taking notes, have already been mentioned. The time spent taking notes, returning and refiling the material, or making repeat consultations is normally in excess of 5 minutes. Assuming this minimum time for 40 per cent of the consultations, the annual usage time is 2,052,000 minutes or 34,200 manhours greater than "look-up" time. Under the proposed system, this additional time can be saved through the microfilm print-out capability.

"It is not realistic to assume that all of these manhours can be converted to productive labor. At least 70 per cent of the time should be transferable, however, since technical manual consultations normally occur when an aircraft is at the dock or gate and a specific job must be done.

"Under these conditions and assuming $3.90 per manhour, $93,400 will be saved annually. Manning standards beginning with the 1967 budget will be reduced accordingly if the proposed program is adopted. This is a savings of about 3 minutes per day per man and is conservative in light of an estimate by Eastern Air Lines that their microfilm system will saving about 15 minutes per day per mechanic or inspector. "

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5.5.4   STORAGE COSTS

Storage costs vary with different airlines. Included in this category are labor, space, racks, binders and cabinets. The following quotations from different airlines provide some examples of these costs.

"Spare Page File Cabinets. The proposed microfilm program will release 109 spare page cabinets costing $295 each and $2,071 worth of spare page racks. These cabinets and racks will be used elsewhere. By not having to purchase new cabinets and racks, $34,226 will be saved if the mocrofilm program is adopted."

"Manual Binders. Of the 11,000 binders that would be released by the microfilm program, approximately 70 per cent or 7,700 binders can be reused. This would eliminate the requirement to purchase new binders for $15,400 over a two to three-year period."

"Space and Filing Cabinets. It was estimated that over 1,200 square feet of space now occupied by technical manuals would be reduced by at least two-thirds. At $30 per square foot, this is an annual saving of $24,000."

5.5.5   NEW TECHNICAL MANUALS COST LESS ON FILM

One airline procured over 75 sets of the DC-9 Maintenance Manual and Illustrated Parts Breakdown with the aircraft at $200 per set. The total bill, not counting binders, was over $15,000. By purchasing only one set and distributing film copies (at $10 per set), the airline estimated that approximately 90 per cent could have been saved.

5.5.6   FASTER TRANSMISSION OF TECHNICAL MANUAL REVISIONS

It takes 2 to 3 weeks to complete the printing, distribution and filing cycle of printed technical manual revisions in continental United States. This cycle is reduced to a maximum of 5 days when a microfilm system is employed. For overseas transmission, the airmail time is 4 to 6 days whereas the equivalent printed manuals sent by parcel post require 30 to

60 days. It is too expensive to transmit printed technical manual revisions by airmail overseas. One airline estimated that revisions to their printed technical manual system in one year weighed over 25,000 pounds. The microfilm time savings from weeks to days are possible due to faster production time, not having to send material to a non-controllable print shop, and receipt of revision material from the manufacturer prior to his sending the material to a local printer.

5.6   AIRLINE ROLL FILM/MICROFICHE
                       SELECTION CRITERIA

5.6.1   GENERAL

The airlines are currently using roll film and microfiche maintenance information systems. This closing portion discusses some of the factors that the airlines had to consider in the process of selecting the microfilm approach best suited to their operations.

5.6.1.1

The following items are some of the tangible and intangible cost considerations Eastern Airlines used in justifying their microfilm approach:

TANGIBLE	INTANGIBLE
1. Costs to Revise Publications	1. Note Taking
2. Printing Costs	2. File Integrity
3. Cost to Distribute	3. File Control
4. Manufacturer's Revision Service	4. Lapsed Time
5. Space and Equipment Cost	5. Fast Retrieval
6. Form Printing and Maintenance	6. Print-out Capability
7. Security File Cost	7. Eliminates Use of Out-Of-Date Forms
	8. Compact Security Storage
	9. Modern System

The following information or criteria also had to be obtained and synthesized by the airlines prior to selecting a particular microfilm system:

1. Is Print-out Required?
2. Depth of Indexing Required.
3. Frequency of Information Retrieval
4. Is Reproduction of Forms Required?
5. Is There a Problem With Out-of-file Material?
6. Is There a Security Requirement?
7. Is There a Need for Maintenance of Superseded Information?
8. Size of Original Documents
9. Condition of Original Documents
10. Is Image Rotation Required?
11. Number of Pages Revised Monthly

12. Number of Pages in Manual(s).
13. Number of Manuals
14. Distribution
15. Space Required for Filing
16. Cost of Space per Sq. Ft.
17. Manhours Required for Filing
18. Manhours Required to Handle Material
19. Printing Costs
20. Cost of Manuals
21. Cost of Revision Service
22. Cost of Binders
23. Cost of Racks

5.6.2. ROLL FILM CONSIDERATIONS

Eastern Airlines, in their early microfilm application studies, found that the largest dollar savings to be realized were in the area of revising and maintaining current technical manuals. This fact, and other file integrity considerations, led to their development of a system employing roll film cartridges. They used the DC-9 maintenance manual in their study as an example to compare the relative cost of roll film in cartridges with a Fiche system using jackets for masters. The DC-9 manual consisted of over 6,000 pages, and since the DC-9 was a recent addition to their fleet, the manual revision frequency was high and involved over 24,000 pages per manual per year.

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They made a detailed comparison of costs before and after a specific revision had been incorporated in the manual. This comparison was based on the assumption that the complete manual is rephotographed each time when roll film is used and only the affected lines are rephotographed when Fiche is used. They used 2,600 images per 100-foot roll and 60 images per Fiche. A distribution of 95 copies was used. Eastern found that when the revision was incorporated in the manual 73% of the lines and 95% of the Fiche cards were affected. The number of cards was increased by 4% and only 4% of the cards required no changes. The high percentage of cards affected illustrates the distribution of revised pages throughout the manual and points up the fact that while only one line out of five on a card may contain revised material, that particular card still has to be revised and duplicates distributed. This comparison indicated a saving of $300 for the initial filming and $240 for each revision for roll film, compared to Fiche.

Figure 5.6.2 shows Eastern's cost for producing microfilm in these two forms. The top chart shows the cost of producing one roll of master film, one duplicate copy in a cartridge, one set of Fiche master jackets, and one duplicate set of Fiche cards. These curves start at a point representing the labor cost for one-half hour, since it is estimated that this minimum time would be required for any operation. The lower "distribution" graph in Figure 5.6.2 shows the cost for one duplicate roll in a cartridge, and an equivalent set of duplicate Fiche cards for a distribution of 1 to 100 copies. These costs would have to be multiplied by the number of rolls or sets per manual to obtain a per issue cost.

Eastern did not evaluate the relative cost of the equipment or of maintaining the original document files. The cost of equipment was readily obtainable but the labor cost of maintaining the original document files on a Fiche line basis, with the depth of indexing required, was estimated by Eastern to be three times that required for a roll system. These costs, together with their desire for complete file integrity (inherent in a cartridge system) and other intangibles, led Eastern to select the 16mm roll film cartridge

Figure 5.6.2 ROLL VS FICHE COMPARATIVE PRODUCTION COSTS
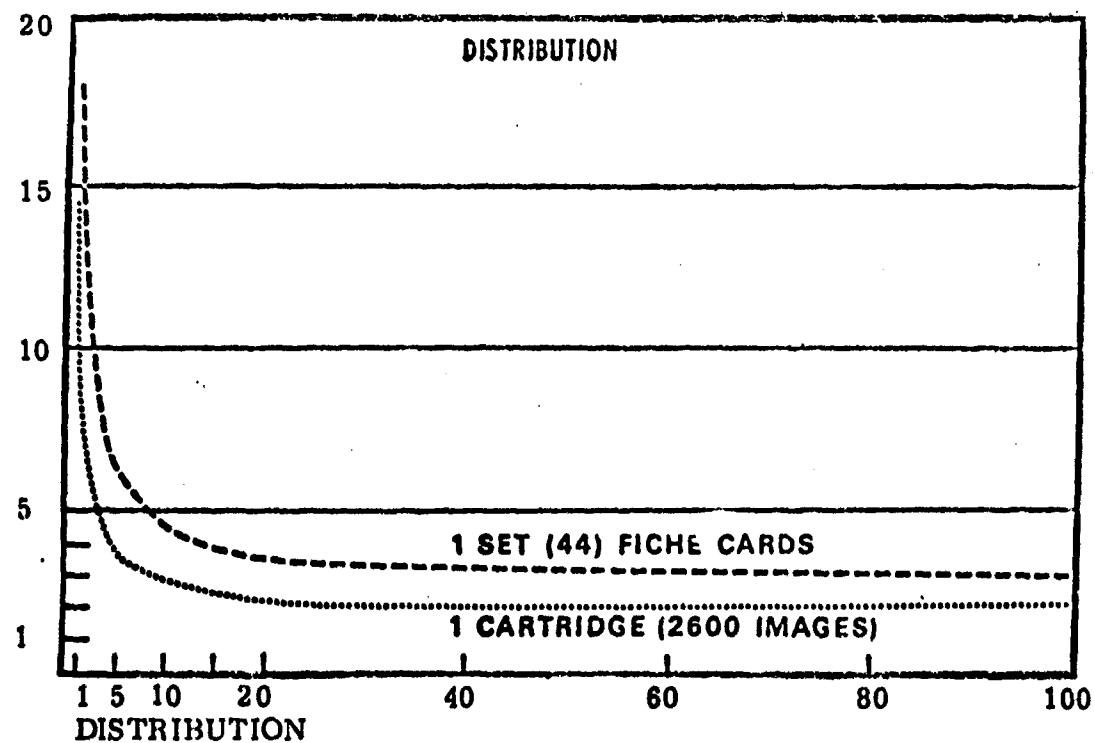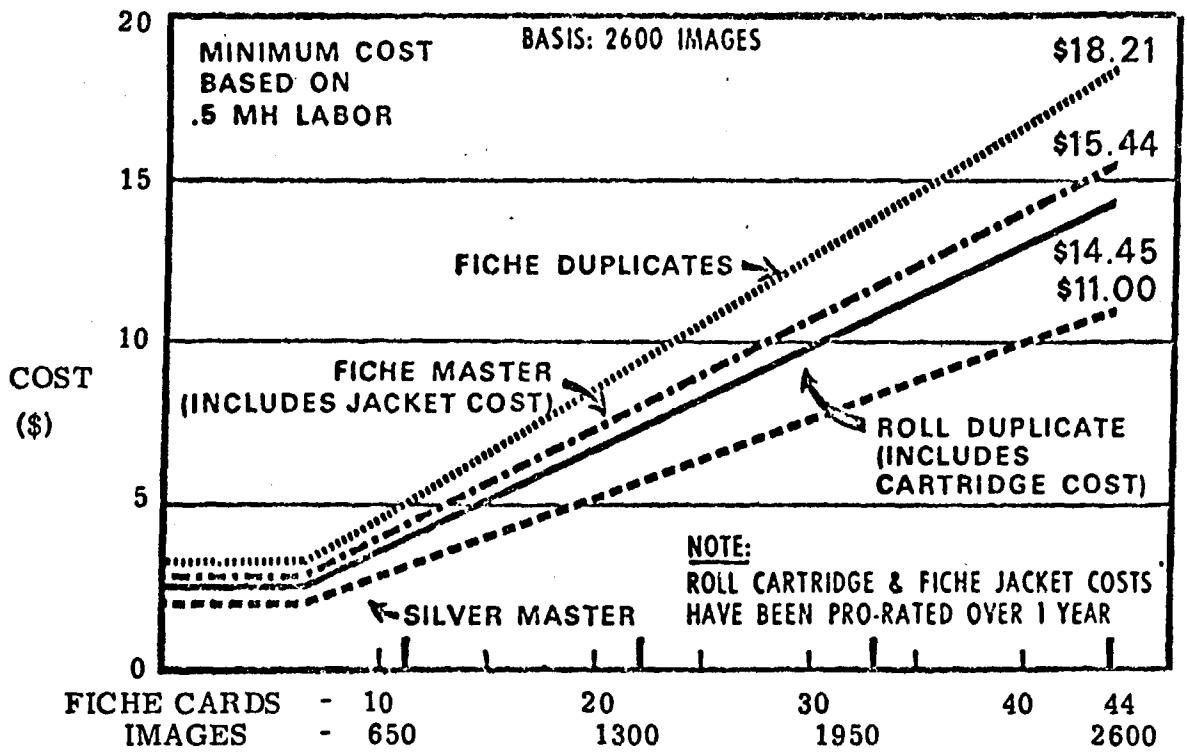
Illustration Source:
Eastern Airlines

approach. Eastern stressed that their cost studies do not indicate that a cartridge system is always more economical than a jacket microfiche system. They stated that in the case of maintenance publications, where the number of pages is high and there is a large distribution with large and frequent revisions, the cartridge system may be cheaper. However, where the technical manual involved has relatively few pages, with small distribution, and revisions are small and infrequent, jacket microfiche has a definite application. Some airlines are using a combination roll film and microfiche concept. Many airlines rejected the microfiche approach because of handling and filing problems and because the sheet of film had no protection from the hands of the user (usually a mechanic).

5.6.3   MICROFICHE CONSIDERATIONS

Other airlines have selected microfiche systems due to their in-house capability of making revisions on an individual page basis. Thus, an urgent revision can be produced and distributed in one day, requiring only a limited number of pages to be refilmed. In a roll film system the entire 100 feet of film must be duplicated (2600 pages). Other microfiche advantages cited by the airlines are:

a)   Readers are cheaper, easier to maintain, and more reliable. Portable battery powered microfiche readers insure a 100% back-up system.

b)   Readers are lighter and portable. Thus, the equipment can be brought directly to the point of use.

c)   Drawings and schematics can be filmed since microfiche readers are available with 14" x 20" screens that project a full 11" x 17" "B" size microformatted drawing.

d)   Microfiche distribution is less troublesome. There are no cartridges to return for re-loading and no labels to be peeled off for new indexing. Regular size envelopes are used for most applications.

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e)   Each microfiche has an eye-legible index title across the top.
When stored in "Acme Visible" racks (ladder-type pockets),
the airline user can quickly scan all the index headings without
touching the microfiche.   No eye-tiring scanning of many film
images is required.

5.6.4   FILE INTEGRITY CONSIDERATION

The aforementioned considerations relative to airline roll film/
microfiche selection criteria   have stressed the economic aspects and the
pros and cons of the equipment and microformats.

However, one consideration looms above these --- file integrity!   The
following quotation from the 3-M Company emphasizes this:
"The pure and simple truth of the matter as concerns the airlines ·is
that economic justification of the system is secondary as a buying
motive to the benefits of file control and integrity inherent in a microfilm
system."

File integrity is of prime importance to the airlines   since Federal Air
Regulation (FAR) require periodic audits of their technical manual
information to assure that it is complete and current.   No missing pages
or revision "write-ins" on the manual pages are permitted.   Microfilmed
manuals are always complete and up-to-date.   Individual pages cannot
be lost, destroyed, or not put in the manuals.

5.7   BOEING'S ATA-100 TECHNICAL MANUAL
                       MICROFILM SYSTEM

See Exhibit E for a brief description of the Boeing Commercial Airplane
Group's ATA-100 technical manual microfilm system.

6.0   MILITARY MAINTENANCE INFORMATION
PRESENTATION SYSTEM STUDIES AND
APPLICATIONS

6.1   INTRODUCTION

This section briefly reviews recent military maintenance information
presentation system studies and applications with particular emphasis given
to microfilm concepts. Library searches were conducted and major
reference indexes were reviewed. Articles that appeared relevant to the
subject area were identified and were obtained for review and analysis. The
literature surveyed covered both military and commercial applications.
Section 5 reviewed the commercial airline technical manual microformat
applications. However, most of the research on this subject has been
sponsored by the military services. To ensure that the latest findings
from recently completed research and on-going studies were reflected in
the report, contacts were established and information obtained directly
from investigators currently working in the technical manual improvement
field and related areas.

No single "cure-all" concept exists today that will solve the many and
varied maintenance information problems that must be considered in
developing optimal "total" (all maintenance level) weapon system maintenance
information presentation systems! Many of the recent "so-called" success-
fully tested maintenance information concepts are publicized as "total"
maintenance information presentation system "cure-all" concepts. However,
this is not valid since most of the new presentation concepts recently
tested were tailored to inclusive maintenance problem areas because of
special interests and funding restrictions.

One must keep in mind that there is no satisfactory, standardized and
scientific job proficiency/job performance aid measurement techniques
available today for evaluating and comparing the new technical manual
presentation systems. Dr. John P. Foley, Jr. of the Air Force Human
Resources Laboratory, who is working on this problem, stated in a recent
Air Force job performance aids research report the following:

> "Job-task performance test procedures together with appropriate
> scoring schemes must be developed to measure both training
> effectiveness and job effectiveness of personnel. Gross systems
> effectiveness measures such as down time and turn-around time
> were used in a current weapons systems job performance aids
> experiment. Such measures are not precise enough to determine
> individual effectiveness. " (Reference 32).

Figure 6.5 provides a resume of some of the recent military technical
manual improvement developments, tests and applications.

The following paragraphs briefly survey studies and applications performed
by the Air Force, Navy and Army. Part of this information was abstracted
from a study conducted by Philco-Ford for the Department of Labor
(Reference 33). Most of the information was derived from official
military test reports which are referenced after each item and cited in
the Reference sheets in the rear of this document.

6.2	AIR FORCE STUDIES AND APPLICATIONS

6.2.1	Introduction

The Air Force and its supporting contractors have been leaders in maintenance
information/presentation improvement studies and applications. Air Force
criteria lists technical manuals and maintenance instructions under the
category - "Job Performance Aids", and many of the studies are
found under this title. The aforementioned Philco-Ford study states:

"The Air Force, more than any other organization, has identified and defined the job performance aid/technical manual field as an important element in weapon system effectiveness." (Reference 33)

6.2.2   EARLY AIR FORCE STUDIES

Early Air Force studies were directed mainly towards improving troubleshooting or fault isolation techniques. The first of a long list of research study documents in this area appeared in the mid-1950s with a report by Berkshire (Reference 34). From 1954 to 1958, the Air Force Personnel and Training Research Center (AFPTRC) sponsored many technical manual studies. The primary emphasis in the studies was on simplification of troubleshooting, including research into what information should be displayed. During this period, the AFPTRC Maintenance Laboratory developed a major research program to explore the possibilities of materially decreasing technical training and achieving important increases in technician performance through improved methods for communicating maintenance information in operational situations. The program included the development and test of experimental job aid materials and devices as well as research on improved presentation techniques for use in technical manuals, film aids and other devices. Unfortunately, this program was terminated in less than two years because of curtailments in funds. (Reference 35).

6.2.3   AIR FORCE STUDIES IN THE EARLY 1960s

The Air Force's technical manual improvement studies during the early 1960 s are cited in a series of reports by Folley et al. (References 36 through 39). The Air Force Human Resources Laboratory (AFHRL) has sponsored research directed toward achieving a better understanding of the many variables that influence the effectiveness of technical manuals. The variables studied included level of information detail, information format, data flow relationships and personnel aptitude.

The most systematic exploratory development efforts, relative to job performance aids, have been conducted by this laboratory since 1960. These have been concerned primarily with aiding the performance of electronic maintenance tasks with particular emphasis given to trouble-shooting tasks. The AFHRL laboratory's unique and far-reaching contribution has been fully proceduralized or non-decision aids for all electronic maintenance activities. The laboratory development and tryout of these non-decision aids was completed in 1968 with the report by Elliott (Reference 40). Currently, the AFHRL is preparing fully proceduralized aids for an Air Force electronics subsystem (Reference 32).

Since 1960, the Technical Training Branch of AFHRL has supported a small but continuing exploratory development program. This has included (A) a systematic investigation to identify important variables concerning job performance aids and the study of the effects of such variables on actual performance and (B) field survey to determine both the current and future of Air Force Electronic Maintenance Technical Data Problems. Dr. John P. Foley, Jr., of AFHRL, has been the Air Force technical monitor of this effort. All of this program has been conducted under contract and the results have been reported in 15 technical reports that are listed in the reference section at tne end of this document. Most of this research has been done by Applied Science Associates, Inc. (ASA) of Valencia, Ohio.

The experimental evidence, to date, indicates that great savings both in system maintenance efficiency and in training efficiency can be obtained by well-designed job performance aids. If a maintenance man uses a good job performance aid, he requires less training and he makes fewer errors in his work (Reference 32).

6.2.4   **AIR FORCE PROJECT PIMO**

One major Air Force research and development program, Project #1316,
just completed will have an impact on the future of technical manuals.
This multi-million dollar project, under the sponsorship of the Air Force
Systems Command, entitled Presentation of Information for Maintenance and
Operation (PIMO), was directed toward improving aircraft maintenance by
providing a better system for presenting maintenance information on the
Air Force technician. Specifically, the program was concerned with identi-
fying what information is actually required by maintenance personnel,
determining the best way of compiling such information and o[timizing the
means of presentation of information to the user. This program advocates a
questionable "task-oriented" maintenance information approach that is
considerably different from that recommended by the Army and Navy. This
controversial program employed "fully proceduralized" non-decision type
maintenance aids for the "fix" portions and SIMM Maintenance Dependency
Chart (MDC) decision-type troubleshooting and other aids for the "fault"
portions. Figure 3.4.7.1 in this document shows and describes the
AUDISCAN equipment employed in the PIMO audio-visual mode. The PIMO
project is evaluated in Boeing document D2-125717-7 (Reference 19).

6.2.5   **AIR FORCE C-5A MADAR CONCEPT**

6.2.5.1   **Background**

The C-5A maintenance system had a design requirement for on-board testing
down to the lowest line replaceable unit (LRU), with a subsequent announce-
ment to the crew as well as a record-keeping entry. Thus, Lockheed
designed an on-board manned (Flight Engineer) malfunction detection
system called MADAR which is an acronym for Malfunction Detection,
Analysis and Recording System.

6.2.5.2   MADAR General Description

The MADAR system automatically monitors approximately 950 points in the C-5A, turns on a panel light at the control station if a failure occurs and prints out a record that identifies the unit requiring replacement. The system also includes a manual diagnostic function that may be used to check the performance of hundreds of selected points without interrupting the automatic monitoring.

The MADAR system consists essentially of two subsystems - automatic and manual (which uses a 16mm maintenance information presentation system) - - - which share a printout unit and a maintenance data recorder for record keeping purposes. The automatic portion operates whenever the switch is "on". However, the manual portion is used at the discretion of the Flight Engineer. The automatic mode monitors LRUs which have signal data outputs amenable to digital techniques. Data sampling, value comparison, limit detection, and malfunction printout are performed automatically according to a preprogrammed plan. The system sequentially monitors approximately 950 data points in the automatic mode. If a failure is detected, the LRU number, time of day, and data are automatically printed out in alphanumeric code, and also, recorded on a maintenance data recorder. The failed subsystem name is illuminated on the Control/Display Subsystem status panel.

6.2.5.3   MADAR Manual(Diagnostic) Mode

The automatic mode is not interrupted when the manual mode is operated. The operator uses the manual (or diagnostic) mode whenever he has any reason to suspect a malfunctioning monitored system. For example, a problem may be indicated in the heading loop. The operator depresses the Flight Control Subsystem entry button and a film frame is projected on the view screen that provides instructions for initiating an analysis of the heading loop. Specific tests points are called up by the film program for waveform display and comparison. As the live waveforms are projected, an analysis film frame is

simultaneously projected showing typical waveform patterns which apply
specifically to the selected data point in the loop with instructions for the
next test point. The operator can progress sequentially through the entire
heading loop examining the loop for faulty signal data flow and thus locate
any faulty LRU that may appear. Diagnostic procedures as well as waveforms
and test point information may be called-up, as required, via the control panel.

Thus, in the manual mode (or diagnostic mode) the MADAR system provides
the operator (Flight Engineer) with a visual waveform display for his use in
analyzing analog parameters that are not amenable to automatic techniques.
Critical analog parameters are analyzed by comparison of simultaneously
projected live waveforms with stored 16mm film (frame) patterns on the
oscilloscope and Digital Readout Unit and the Microfilm Data Retrieval Unit
respectively as shown on Figure 6.2.5.3.

Manual mode operations are controlled by the Control Display (C/D) Group at the
Flight Engineer's station as shown in Figure 6.2.5.3. The three C/D group
equipment units provide centralized control of the MADAR system as follows:

Microfilm Data Retrieval Unit:
- Is capable of retrieving, in a random manner, any one of 10,000
  frames (16mm film) of maintenance information
- Contains a film strip memory with a storage capacity of approximately
  1.5 million bits in addition to the 10,000 frames of maintenance
  information used for visual presentation
- Has an access time of 4 seconds (average)
- Provides rapid film updating via 16mm film "magazine" replacement

Control and Sequencer Unit
- Contains the digital logic necessary to control the operation of the
  Occilloscope/Digital Readout Unit, Data Retrieval Unit, and the
  Manual Multiplexer

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**Digital Bits Identify/
Control:**

1. Oscilloscope Settings
2. Test Point Addresses
3. Choices
4. Film Frame Addresses
5. Parity Program
6. Film Program

Visual Information
for Display to Operator

MADAR FILM FRAME
FORMAT

Microfilm Data Retrieval Unit

Oscilloscope & Digital Readout Unit

Control & Sequencer Unit

MADAR CONTROL-
DISPLAY GROUP

FLIGHT
ENGINEER'S
STATION

Figure 6.2.5.3   LOCKHEED C-5A MADAR SYSTEM
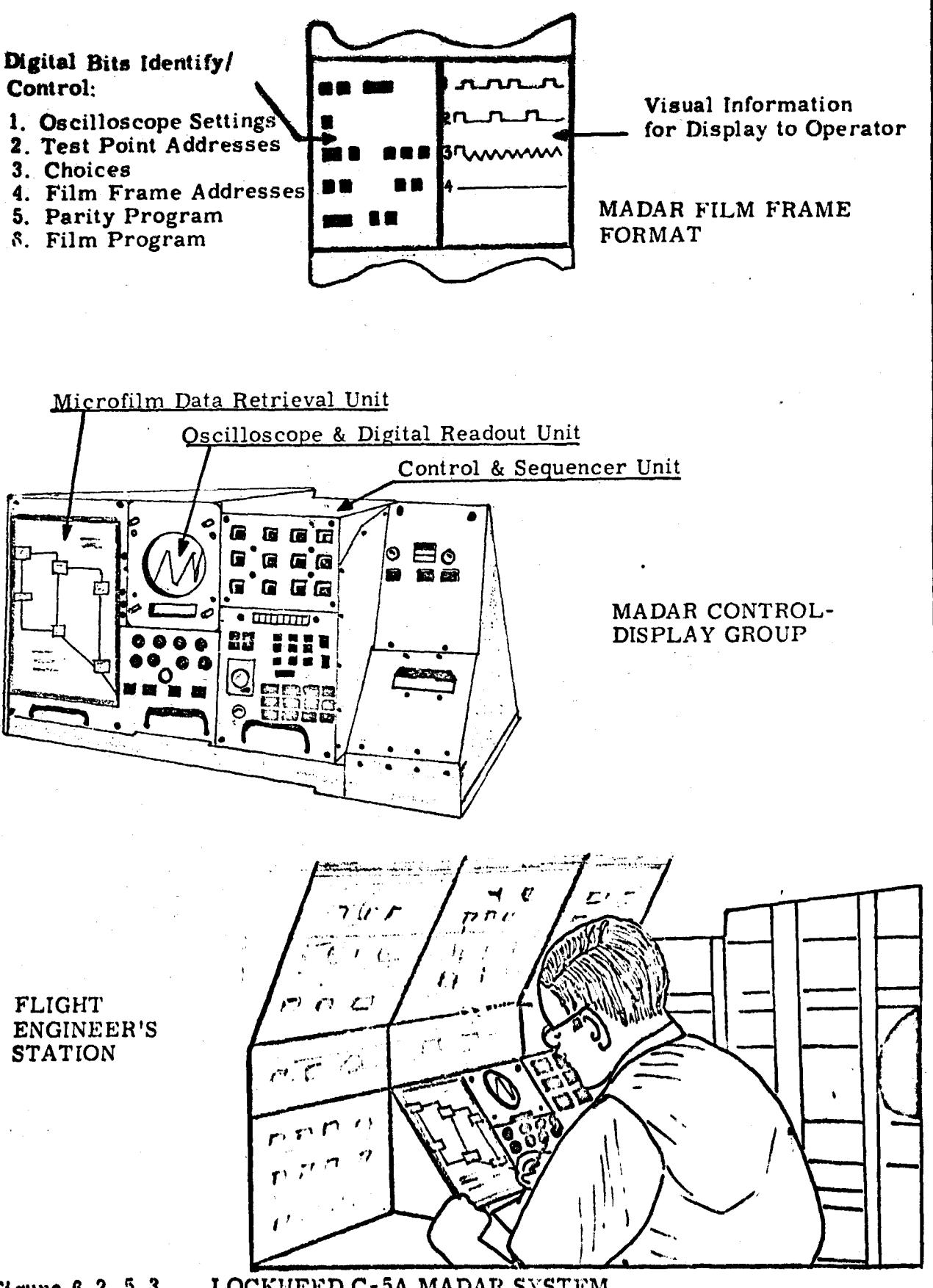
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- Controls the routing of incoming and outgoing data to the Control Display Group
- Provides choice of switches to operator
- Permits immediate subsystem selection and status determination
- Provides random addressing of test points

Oscilloscope/Digital Readout Unit:

- Is completely and automatically programmed from coded information contained on the film
- Contains a dual trace, storage, CRT (daylight viewing)
- Incorporates an AC-DC digital voltmeter with a bandwidth from DC to 2 Mc and capability for quadrature voltage measurement
- Incorporates an oscilloscope that can be AC or DC coupled and has a bandwidth from DC to 10 Mc
- Provides trace storage capability

6.2.5.4   MADAR Manual Mode - LRU Status Determination

LRU status determination by the manual mode is similar to the method used for the automatic mode. The operator selects the desired subsystems and begins the film preprogrammed interrogation of the subsystem test points. As each live waveform appears on the oscilloscope, a corresponding film frame is displayed on the microfilm Data Retrieval Unit's screen. This film frame provides either information or waveforms to the operator in a manner that permits him continued operation "choice". As choices are made, the operator progresses through the programmed diagnosis of the selected subsystem. When the operator's choice depicts an improper waveform, and a subsequent faulty LRU, the actuation of the choice switch produces an output to the Print Out and Maintenance Data Recorder Units. The printout includes LRU number, subsystem identification, and time.

Random access to any test point may be obtained by entering the test point address through the C/D keyboard. The test data signal is thus displayed without

regard to any diagnostic sub-routine. This operation would be performed by an experienced technician doing detailed troubleshooting.

6.2.5.5   MADAR Maintenance Information Presentation Concept

Approximately 10,000 coded maintenance information film frames are used in the 16mm presentation system. A typical film frame format is shown on Figure 6.2.5.3. The digital data code appears on the left and the technical information to be displayed on the viewing screen is shown on the right. A single light source is used for projection. The digital data, however, is split off and projected onto a photovoltaic cell bank for decoding. The various digital codes represent choices, addresses, and control settings for the oscilloscope and digital readout unit. The complete programming of the oscilloscope and digital readout unit by film frame data permits its utilization by persons not generally familiar with test equipment. The visual information data provides typical waveforms for operator comparison. Other film frames provide diagnostic routines, detailed LRU information, and other maintenance information. For additional data on MADAR, refer to Reference 41.

**6.2.6   EFFECTS OF NEW CONCEPT APPLICATIONS IN THE
                AIR FORCE**

The aforementioned Air Force research efforts described encompassed studies dealing with the effectiveness of improved maintenance information presentation concepts. The following paragraphs briefly summarize the reported results of introducing these recent improved maintenance information concepts into specific Air Force maintenance situations or environments.

6.2.6.1   Concepts that Reduced Maintenance Training Time

Folley and Munger (reference 38) describe a study by Hoehn and Aukes that tested the effectiveness of a new troubleshooting guide for an electrical system. The major findings indicated that the troubleshooting ability of untrained and trained men can be increased by improved procedural instructions. A study by Hoehn and Wardell (reference 38) indicated that Air Force technicians with a

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median of seven months experience did as well as technicians with a median
of 21 months experience when both used a new troubleshoot.ng guide. The less
experienced technicians, using the new guide, employed more efficient proce-
dures than did the experienced technicians, with conventional technical manuals

One concept that reduces training time and subsequent maintenance time, and
is now employing microfilm presentation devices, is Programmed Instruction
(PI). Many current PI courses employ the printed approach but the advent
of low cost microfilm systems is reducing this trend. Reference 42
describes overall Air Force Programmed Instruction developments as well
as specific courses employing visual display units. Reference 43 PI
summary report, released by the Naval Air Technical Training Command,
describes a large number of military-oriented PI technical papers. This
report states that in 1968 Navy Air saved over 235 man-years in training
time due to PI. PI is mentioned in this document since it involves training
maintenance manual content improvement. Also, in the future, PI techniques
will increasingly employ microformats for training and for presenting
programmed operation-maintenance instructions (See paragraphs 4. 5. 7 thru
4. 5. 7. 3).

6.2.6.2   Effect of an Air Force PIMO Program

The PIMO study results, released in May 1969, may be summarized as
follows. Experienced and inexperienced Air Force technicians performed
maintenance on C-141A aircraft, using PIMO Job Guides presented in audio-
visual and booklet modes. Performance was measured in terms of time to
perform and procedural errors. The performance was compared with the
performance on the same jobs by a control group, i. e., experienced techni-
cians performing in the normal manner (using conventional technical
manuals). The following conclusions were drawn from the test results:
a) after initial learning trials, both experienced and inexperienced
technicians, using PIMO data concepts, can perform error-free maintenance
within the same time as experienced technicians performing in the normal
manner, b) inexperienced technicians perform as well as experienced
technicians when both use PIMO data concepts. Thus, parts of the PIMO

task-oriented concept, that permit more rapid utilization of maintenance
personnel, will be a requirement in future Air Force programs.

6.2.6.3   Effect of Slide/Tape Program Test

The Air Force tested other improved maintenance information concepts,
including a new display technique using taped lectures/slides versus printed
technical manuals. One experiment demonstrated that a taped lecture, with
logic flow diagrams on slides projected directly onto the control panel of an
electronic console, could serve both as a job performance aid and teaching
program aid. When the same logic diagrams were employed in a technical
manual, training/maintenance time was longer than with the tape/slide
program (Reference   44   ).

6.2.6.4   Effect of Air Force SIMM Tests

The Air Force also tested the Navy developed SIMM technical manual
concept (paragraph 6.3.1) as a classroom teaching aid, using the WILCOX 482
TVOR as a test vehicle. Another Air Force SIMM test compared SIMM
manuals with conventional technical manuals in training and maintenance
situations for the AN/FPS-27 and MA-1 systems. These large Air Force
tests resulted in faster maintenance information retrieval and troubleshooting
response, as shown in Figure 6.2.6.4. The PIMO Troubleshooting Aid (TSA)
tests (partially SIMM) also resulted in reduction in maintenance time. Thus,
the Air Force, in limited electronic/ground communication equipment areas,
is moving ahead with the SIMM approach in conjunction with Air Force
Project #949. Westinghouse recently received an updating contract for
AN/FPS-27 SIMM manuals, and Hughes anticipates an updating contract
for AN/FPS-27. See Boeing Document D2-125568-1 for additional details
on the Air Force SIMM tests and a detailed bibliography on other SIMM tests
and applications. Boeing Document D2-121371-1 shows how SIMM may be
displayed (in future programs) via various 35mm roll film modes. See
References 45 and 46 for additional information on these two Boeing study
documents.

PROGRAM	AGENCY	TEST RESULTS
AN/SPS-29 Radar Transmitter Receiver	Coast Guard	Troubleshooting Time Reduced 47%
Pershing Missile	Army	Training Time Reduced 50%
Hawk Missile	Army	Large Reduction in Troubleshooting Time
F-106 (MA-1) Radar and IR Subsystem	Air Force	Missile Downtime Reduced Approximately 36%
Wilcox 482 TVOR	Air Force	11 to 38% Reduction in Maintenance Manhours
MK363 Missile Electrical System Test Set	Navy (NUWS)	Faster Maintenance Information Retrieval and Troubleshooting Response
CU-1441/BRR	Navy	Troubleshooting Time Reduced 27% (Class C Technician)
AN/FPS-27 Radar System	Air Force	Training Time Reduced 50%
AN/APN-59R	Air Force	11 to 38% Reduction in Maintenance Manhours
C-141A Aircraft PMIO Program ⚠1	Air Force	Training Time Reduced 33%
		Troubleshooting - 11% Reduction in Performance Time and 92% Reduction in Maintenance Errors

⚠1 Only SIMM maintenance dependency charts were used (for troubleshooting purposes). Integrated (electrical-mechanical) schematics were substituted for SIMM precise access block diagrams and block text schematics.

FIGURE 6.2.6.4   SUMMARY OF SIMM TEST RESULTS

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6.2.6.5 Effect of MADAR System (Air Force)

The MADAR aircraft integrated data system approach will be a requirement in future large aircraft systems. The B-52H is being used as a test bed for a new airborne integrated data system developed by Garrett AiResearch. This new system will monitor considerable more data points than done in MADAR. Additional information on the use of microformats for displaying computer-generated/controlled maintenance information may be found in section 7 of this document, where Computer Onto Microfilm (COM) and magnetic tape-to-microfilm conversion are discussed.

6.2.6.6 Summary Remarks on MADAR System

One lesson learned in the MADAR program is that the software development program is often greater than the hardware development program. Another lesson learned was that an extensive verification program must be planned early and instituted to evaluate the performance of the "total" system from signal conditioning input to the 16mm maintenance information film and computer programming. This involved individual subsystem, system and total integrated verification (ground and flight).

MADAR also demonstrated that the most important factor behind the design of any large automated CRT/microfilm maintenance information program is the system/operation-maintenance analyses including extensive failure effects analyses. These involved Design, System, Logistics and other Engineering groups (Reliability, Safety, Maintainability, etc.). The results of these exhaustive analyses resulted in the definition of the following:

- test point selection and assignment for automatic or manual mode monitoring
- logic diagrams for film program (manual mode)
- computer routines (automatic mode)
- determination of signal conditioning requirements
- test procedures for "non-wired" LRUs

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Each analysis or investigation resulted in logic diagrams necessary for preparation of the film program. The diagram provided test point selection priorities for specific diagnostic routines, instrument indications, and step-by-step procedures for systematically isolating a fault. These diagrams were used principally by the manual mode but were also applicable to the automatic mode. Trade-offs resulted in a ratio of 2.3:1 for automatic-to-manual test points.

Approximately 1800 C-5A LRUs are monitored and 50% of these do not interface electrically with the MADAR system. Thus, test procedures for "non-wired" LRUs were developed since many faulty LRUs can be isolated by clever manipulation of existing controls. Straightforward troubleshooting routines were prepared which followed logical sequences. The procedures were placed on the film and, therefore, became standard procedures which can be accomplished by persons having a wide variation of training /experience.

Finally, a complex multi-interface system like MADAR must employ a computerized configuration control and indexing system. Thus, in MADAR, a significant portion of the computer memory was accessible by keyboard entry to permit limited program alteration and to provide a means to input data for storage. Operator instructions were detailed on the various film frames of each subsystem investigated. These film frames were accessible to the operator by depressing the appropriate status annunciator pushbutton and selecting the desired operation from the index appearing on the viewing screen.

6.3 NAVY STUDIES AND APPLICATIONS

6.3.1 SIMM/DD Maintenance Information Concepts

The Navy has pathfinded many new technical manual presentation concepts, including the Symbolic Integrated Maintenance Manual (SIMM) Concept which is evaluated in Boeing document D2-125568-1 and its corollory engineering design communications discipline called Design Disclosure (DD). DD formats comprehensively map the system/equipment configurations in a concise and understandable SIMM manner and form a unified scheme for acquiring the basic data required in a variety of engineering and logistics disciplines. The SIMM maintenance dependency charts (MDCs) have been proven, in field tests by all the services, to be an improved troubleshooting media. However, they are difficult and expensive to create after the design has been accomplished. The DD concept solves this problem by placing the responsibility for developing the MDCs (DD Design Outlines) on the design and system engineer. Ralph DePaul of Philco-Ford, one of the originators of the SIMM concept, recently stated that Philco-Ford has perfected a computerized MDC development approach in their System Performance Analysis Display (SPAD) concept. For additional information on the DD concept, refer to Boeing document D2-125771-3 "Evaluation of Navy Design Disclosure (DD) Concept". For additional details on how SIMM may be effectively presented via microform techniques, refer to Boeing document D2-121371-1, "The SIMM Concept and Its Future". (References 47, 45 and 44)

6.3.2 Head-Worn Maintenance Information Viewer

The Navy, in 1964, evaluated a laboratory model of a head-worn film-strip viewer which was synchronized with an audio tape (head-gear) system as a vehicle for presenting programmed information for maintenance task performances (Reference 48). The head-worn device, shown in Figure 6.3.3 was a light-weight unit holding a 35mm film of up to 75 frames and had a knob for advancing and rewinding the film. An accompanying narrative was obtained from an audio tape source connected to the headgear by cable. Two provisions were made for starting the audio. The film-advance

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FILM-ADVANCE
KNOB

AUDIO START
SWITCH

FOCUS CONTROL
(2 Feet to ∞)

FOR
MAINTENANCE
INSTRUCTIONS
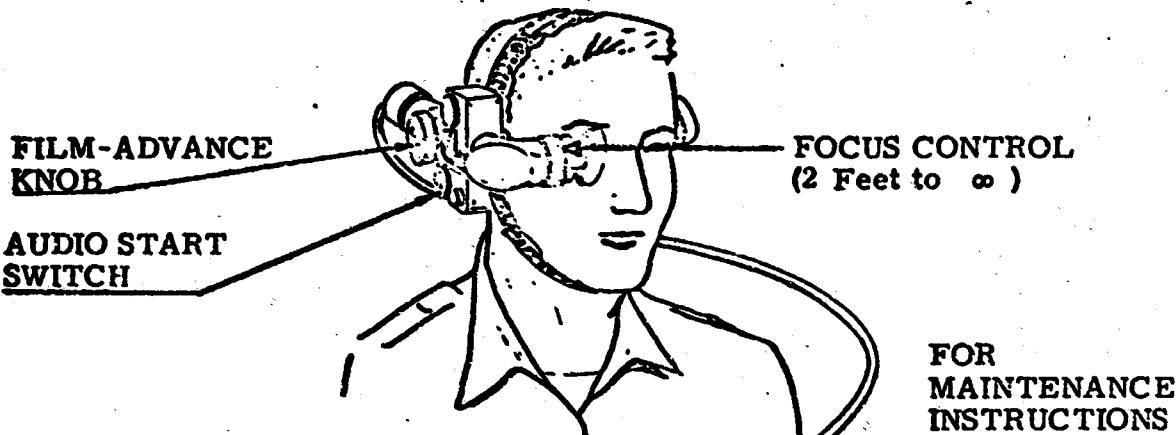
NAVY HEAD-WORN 35-MM FILM/AUDIO DEVICE

Video images
projected on
partially silvered
mirror of "see-
through" eyepiece

FOR
PILOT
OPERATING
INSTRUCTIONS
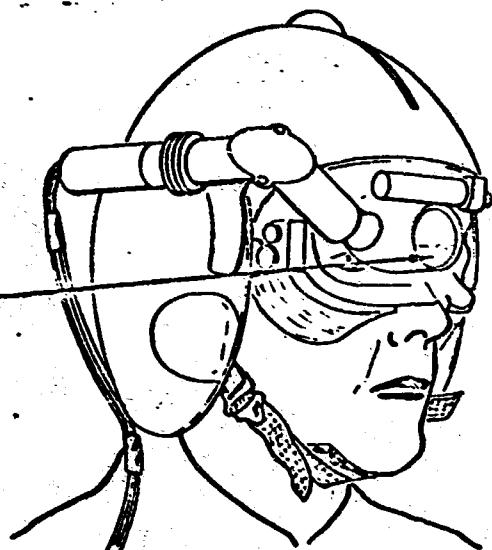
BELL HELICOPTER HELMET - MOUNTED DISPLAY DEVICE

Right eye used for
sensor projected
imagery and left
eye for all other
functions.

NAVY /
AIR FORCE
PROJECT
(Hughes Aircraft)
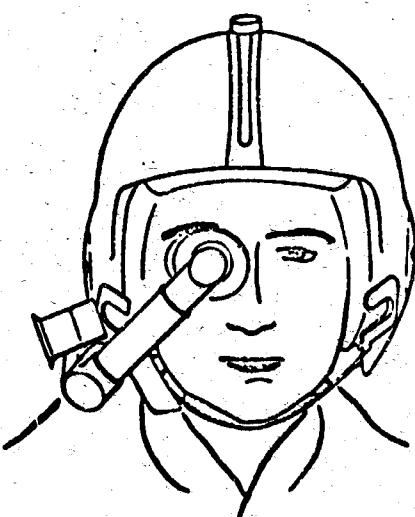
OCCLUDED-EYE HELMET-MOUNTED DEVICE

Figure 6.3.2   HEAD-WORN DISPLAY DEVICES

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knob closed a switch momentarily for each new frame brought into view
or a pushbutton, mounted toward the lower rear of the film barrel, could
be used to start the audio. In use, the wearer's environment is visible to
both eyes while an image of the film is presented to one eye via a semi-
transparent mirror. Attending to one image or the other is accomplished
by focusing the eyes on either an environmental object or the plane of the
film image. The device was used in the laboratory to appraise its capability in
relation to certain display and environmental variables. It was also
compared with a larger audio-visual device whose effectiveness had been
previously established.

The Navy tests concluded that the head-worn device was usable under a
wide range of viewing conditions. When the two different audio-visual
devices were compared as aids in aligning radar display equipment, there
was no significant difference in alignment time. The head-worn device
was preferred by six of the twelve participants in the study, with four
preferring the larger audio-visual comparison device and two expressing
a preference for printed maintenance technical manuals. The results
supported the feasibility of the head-worn device for performing tasks
where there is insufficient space for larger displays and where operator
mobility is a requirement.

6.3.3   Head-Worn Operation Instruction Viewers

The Navy investigated the idea of helmet-mounted operation instruction display
units over 15 years ago in Project Oversight at the Naval Research Labora-
tories. The unit described in paragraph 6.3.2 was originally conceived by
Hughes Aircraft for the Navy and was called "Electrocular". This audio-
visual unit was initially a visual viewer and employed a head-worn cathode-
ray tube (CRT) display device. The CRT was 1-inch in diameter and the
entire unit weighed about 30 ounces. Insufficient brightness and resolution
from the then available tubes, plus the bulky and weighty helmet, slowed
progress.

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Extremely lightweight cathode ray tubes no more than 1-inch
in diameter and with improved brightness and resolution have recently
become available. The military services are now testing these units.
They provide a simple way of presenting real-time infrared, radar or
low-light television imagery to flight crewmen, as well as operation and
maintenance instructions to others. The Bell and Hughes Aircraft units
shown on Figure 6.3.2 are two CRT-type devices being tested. Other
units have been developed by Autonetics, Electro-Optical, Honeywell,
Perkin-Elmer and Texas Instruments (Reference 49).

6.3.4

An experimental locator for troubleshooting a radio transceiver
was developed and evaluated by Rigney and associates (References 50
and 51). The fault locator was a small, circular, plastic job aid
incorporating circuit-front panel relationships necessary for fault local-
ization. The technician noted malfunction symptoms during the checkout,
entered these symptoms on the aid, and looked up the indicated mal-
functions in an accompanying manual.

6.3.5   Forecast Concept (Navy Application)

The Army FORECAST approach (paragraph 6.4.3) was also applied and
tested in the Navy environment (Reference 52). Following a FORECAST
analysis of the Long Range Navigation (LORAN) System, a technical
manual and training program was developed containing the FORECAST
techniques. The graduates of the FORECAST program identified
approximately three times as many malfunctioning parts as did the graduates
of conventional training.

6.3.6   Maintenance Information Automated Retrieval System
                          (MIARS)

The growing volume problem of the paper technical information system
required to support maintenance activities in the Navy (See Figure 1.2.1.2
and 1.2.1.2 -1) led the Navy several years ago to initiate a technical

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manual improvement program. This was necessary since the growing volume had caused serious management/user problems in the area of storage, file integrity, data retrieval, time and cost to update and time to distribute the material.

Navy studies were made of all types and combinations of equipment for the presentation of maintenance data such as audio visual presentation, TV projection, computer storage and retrieval and automated microfilm retrieval which offered the best solution to the problem.

Next, the MIARS Program was established to evaluate and develop proposed microform techniques, operating procedures and equipment requirements for Navy-wide application at the earliest practical date. (Reference 53). The MIARS Program, initiated by CNO Instruction 4790.1 dated October 1968, promises to have an explosive effect on printed military technical manuals as they are known today (Reference 54). MIARS, which stands for Maintenance Information Automated Retrieval System, is a program or group of programs designed to transform as many hard copy technical manuals as possible into microforms.

Three of the major microfilm systems that MIARS has tested and is evaluating and using as a baseline for developing official military specifications covering technical manual microform format and reader-printer/printer requirements have been described, in connection with the equipment they employed, in section 3 of this document. In the forefront of the new microfilm system designs, are airframe manufacturers who have put together software packages for storage and retrieval of microfilm technical manuals so that aircraft can be maintained with such systems. There are many names for these systems and they all have similar features. Three of these are: WSMAC or (Weapons Systems Maintenance Action Center),(paragraph 3.4.3.3), a special NARF designed microfilm storage and retrieval system (paragraph 3.4.4.2.1) and RAPIDS or (Rapids Automated Problem Identification System) (paragraph 3.4.4.2.2).

The purpose of MIARS, according to Commander G. E. Bethune, MIARS Task Force Director, "is to improve weapon system readiness by reducing the percentage of NORM time" (Reference 2). Figure 6.3.6 shows the major milestones of the MIARS Program as of early 1969.

6.3.7   Naval Air Documentation Improvement Plan

The Navy Air Systems Command has established the Documentation Improvement Program (DIP) in accordance with NASC letter AIR-415, dated 15 December 1968. The goal of this five year program, scheduled to start later this year, is to "provide dramatic improvement" in all the types of documentation needed to operate, handle, and maintain Naval Air weapons, weapon systems and related equipment. This comprehensive R&D program is aimed at improving "software" support via (1) employment of the latest state-of-the-art technology and (2) employing a combined alternative actions approach.

Seven basic types of documentation support are being addressed by this program. Initially, primary attention is being given to the adequacy of engineering drawings and related data, technical manuals or instructions, test and program tapes, and technical directives to maximize the benefits to the fleet and fleet support maintenance activities.

DIP's goal is to insure that adequate technical documentation is in the user's possession when he needs it. More specifically, DIP seeks to obtain more timely and useful communications between the "hardware" design engineer and the user, to minimize the quantity of information being provided and/or provide for easier storage and retrieval of delivered information, and to insure that necessary documentation is delivered concurrent with "hardware" delivery.

This program will cover documentation improvements in many areas outside the realm of microformats. However, the MIARS microfilm program will be a part of the DIP Program.

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Illustration Source: Commander G. E. Bethune Presentation (Reference 2)

MAJOR MILESTONES	1968	1969	1970	1971	1972
1. AUTOMATED RETRIEVAL TEST AND EVALUATION					
2. DEVELOP PCR FOR MIARS EFFORT					
3. DEVELOP SPECIFICATIONS AND STANDARDS		NAVAIR	DOD	INDEF	
4. IMPLEMENTATION OF MICROFILM SYSTEM AT ALL NARFS	PILOT		COMPLETE PROGRAM		
5. DEVELOP SYSTEM FOR CONVERTING COMPONENT, ACCESSORY, ELECTRONIC, WEAPONS LOADING AND MISCELLANEOUS TECHNICAL MANUALS TO MICROFILM					
6. DEVELOP PLAN FOR OPERATION AND ORGANIZATION OF THE CENTRAL REPOSITORY					
7. DEVELOP TRANSITION PLAN FOR DEPOT, INTERMEDIATE AND ORGANIZATION LEVELS		DEVELOP IMPLEMENT			
8. DEVELOP TRANSITION PLAN FOR THE TRAINING COMMAND		DEVELOP IMPLEMENT			
9. DEVELOP SYSTEM FOR SUPPLYING OTHER DATA IN 16MM MICROFILM CARTRIDGES		DEVELOP IMPLEMENT			

Figure 6.3.6 MIARS PROGRAM SCHEDULE

6.3.8 Other Navy Programs

The Navy has other potential maintenance information presentation development concepts and studies in progress such as EDMICS (Engineering Data Management Information Control System), TMMICS (Technical Manual Management Information Control System), and the Field Change Identification Guide (FCIG) program that used the ATS (IBM)-PHOTON system. The TMMICS concept employs a new maintenance (technical manual) information categorizing system (Class I information is used daily, Class II - infrequently and Class III - rarely used) that controls the storage and retrieval aspects of this multi-presentation system (Reference 54).

6.4 ARMY STUDIES AND APPLICATIONS

6.4.1

The Army has also been very concerned with improving the efficiency of maintenance personnel performance. Hence, many of its study efforts related to job performance aids have been directed toward developing improved maintenance technical manuals. Several major technical manual improvement programs in recent years were carried out by the George Washington University's Human Resources Research Office (HumRRO) operating under contract with the Department of the Army.

6.4.2 MAINTRAIN Project

The HumRRO MAINTRAIN Project involved the development of a maintenance manual designed to permit trained technicians to troubleshoot complex electronic equipment faster and more accurately (Reference 55). An experimental technical manual covering troubleshooting the Nike Ajax missile system and its test equipment was evaluated by means of an objective test using two groups of inexperienced technicians to locate malfunctions in the system. The experimental group using the improved maintenance manual accomplished troubleshooting substantially faster and more effectively than

did the control group which used schematic and functional diagrams found
in the conventional technical manuals.

6.4.3   FORECAST Project

The HumRRO research, under task FORECAST, involved related efforts
that included the development of improved training methods coupled with
improved job methods, aids, devices and data formats. Conclusions were
drawn relative to the "total" FORECAST approach rather than the
effectiveness of individual aids. Major products included a series of trouble-
shooting guides for isolating system malfunctions based upon signal flow
information. The job aids enable the repairman to do his own thinking,
while still benefiting from the deductions made by experienced systems
analysts who had structured the system in the optimum manner for
troubleshooting. The results indicated that the FORECAST approach
produces technicians in approximately 60 percent less training time than
that required with conventional techniques (Reference 56   ).

6.4.4   A-VIS Project

The Army Missile Test and Evaluation Directorate conducted a study of
the effectiveness of a new Audio-Visual Information System (A-VIS) which
was compared to standard technical manuals as maintenance job aids
(Reference 57). The A-VIS presentation equipment evaluated was an
experimental device which employed schematics, block diagrams and
printed instructions on film chips. The unit contained over 10,000 film
chips plus 80 hours of audio instruction stored on magnetic mylar tape.
Selection of a film chip was initiated by punching out a code number on a
keyboard. Visual information was displayed on two screens (9 x 12 and
12 x 24 inches) which could be used concurrently or independently. Audio
information was also accessed via the control console using an eleven-
bit code on the film chip.

The study evaluated four other information presentation modes; audio
information system (AIS) which used the audio portion of A-VIS, visual
information system (VIS), programmed technical manuals (PTM) in which

all of the A-VIS information was presented in book form, and technical manuals.

The results tended to show a marked superiority of the visual and programmed technical manual modes, with conventional technical manuals and audiovisual presentations scoring low. The principal contribution to the superiority of the automated modes was in informational content. However, the contribution made by the automatic video retrieval system was significant, and enhanced the value of the data programs. Several hypotheses were advanced to explain the poor showing of audio presentation: (1) the use of two senses simultaneously under the requirement to react with some time urgency tends to induce a measure of confusion; (2) audio presentation research of a pertinent detail; (3) the female audio voice used did not inspire confidence among the technicians (Reference 57).

6.4.5   **Army Officer Checklists**

A suggested format for a handbook was developed in this HumRRO project covering what the inexperienced unit officer needs to know about electronic equipment operational and system checks. It concluded that while existing manuals and directives provide helpful guidance, checklists in easily readable form are needed by the inexperienced officer who is expected to perform in a short time. These checklists should enable quick and easy access at job location and should emphasize essential knowledge and skills required.

6.4.6   **FLATTOP Concept**

6.4.6.1

The ship, the USNS CORPUS CHRISTI BAY, is the Army's first and only floating aircraft maintenance facility and has been tagged Project FLATTOP. The ship's technical data library, which contains more than 1,250,000 documents on microfilm, is described in paragraph 3.4.3.4.

6.4.7   Proposed Sentinel/Safeguard Maintenance Data System

The following information was extracted from a data specification for the
Sentinel Weapon System by the Western Electric Company (Reference 58).

6.4.7.1   General Description

The Maintenance Data System (MDS) is a data and hardware subsystem for
the operation and maintenance of the proposed Sentinel Weapon System. The
hardware consists primarily of a video tape subsystem for the storage and
display of programmed data. Programmed data refers to the organization
of the operation and maintenance information required for each task. Proce-
dural data in the form of operation and maintenance information is
organized into a complete set of explicit instructions for each task.
Support data, in the form of equipment-oriented diagrams derived from
equipment engineering drawings and technical logistic data, is referenced
or included at the appropriate place in the maintenance routines. Programmed
data interfaces with and supports computer-run maintenance diagnostics,
and fault detection and location indicators of the Weapon System.

The equipment configuration of MDS comprises a central file of video
tapes and disc buffers from which the data requested is presented on
mobile cathode ray tube display units (or sections) assigned to designated
work areas. The major portion of MDS data is prepared for display by the
video tape subsystem. However, in order to provide complete data
coverage in all areas of maintenance, the MDS provides MDS data frame
printouts for maintenance in special environmental applications (e.g.
the missile launch cell and other areas).

6.4.7.2   Video Tape Subsystem (VTS)

MDS equipment is located in each major equipment building. In each
building, there is a central file of data that is displayed on mobile data
display sections in the work areas. Personnel can retrieve desired data
from the central file via a keyboard on the data display. All information
in the central file is available to any data display section associated with
that central file. The content of the on-site central files is controlled
from a Central Control Point to assure current and accurate information.
The video tape subsystem equipment shown in Figure 6.4.7.2 represents
the basic units intended for a Central Control Point and an on-site installa-
tion.

6.4.7.3   Central Control Point Equipment Functions

a.   Data Input Section - Converts MDS data, in the form of keypunched
      35mm microfilm aperture cards, into video and control signals
      suitable for recording on magnetic tape and displaying on a cathode
      ray viewing screen in the Data Display section. The section consists
      of: equipment for automatically converting the keypunched MDS
      retrieval code into a binary signal that represents the frame address
      of the film image, a flying spot scanner for scanning the microfilm
      aperture and converting the information into a high resolution video
      signal for recording on magnetic tape, and a console display section
      for verification of the data recorded. A teletypewriter is used for
      addressing the system control section and for printing activity logs.

b.   System Control Section -   Contains the master logic electronics
      which performs the necessary digital and digital-analog conversion
      functions for control of the tape, tape electronics, buffer and filing
      electronics sections.

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USE FOR TYPEWRI1 MATERIAL ONLY
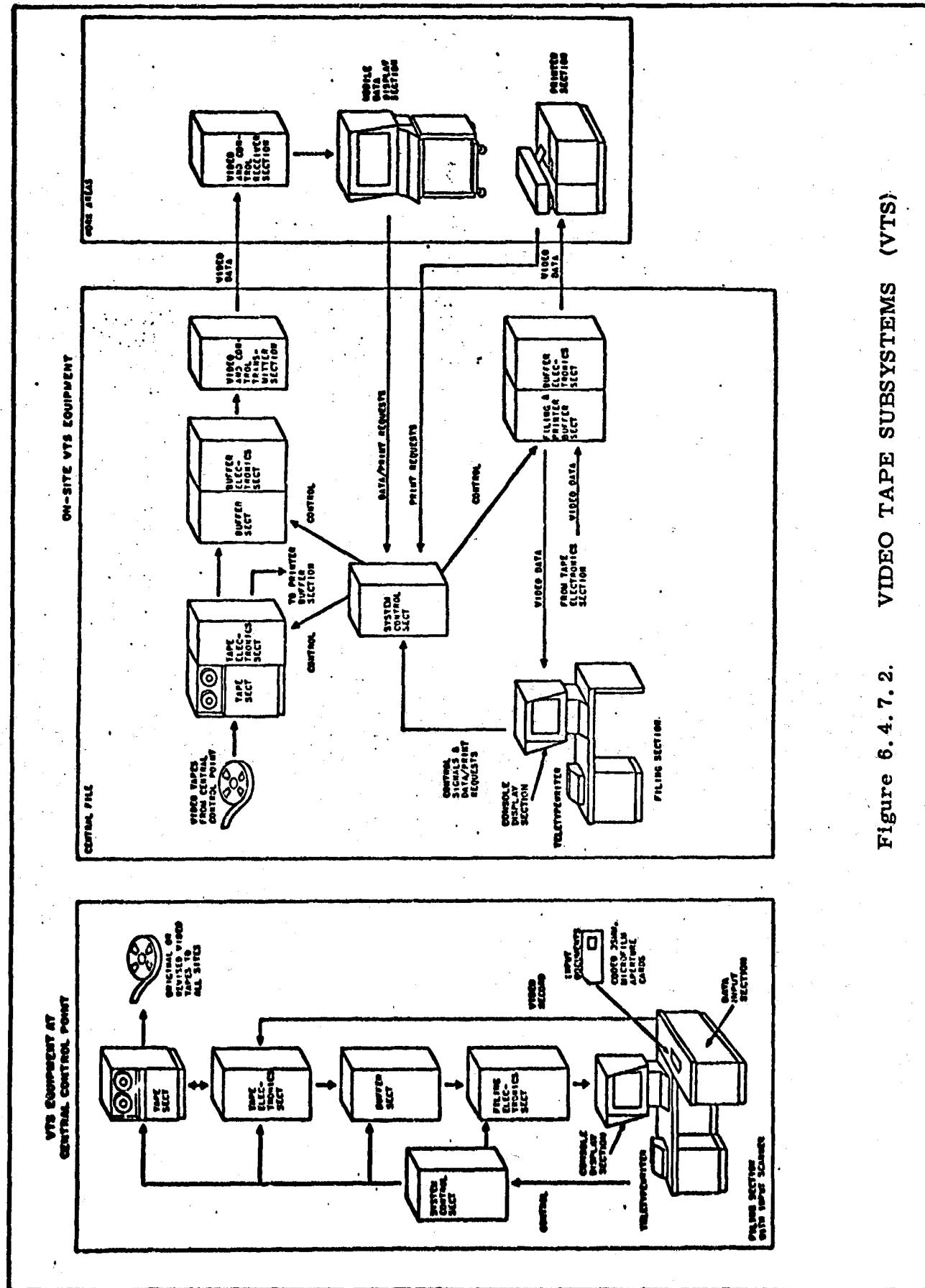
Figure 6.4.7.2. VIDEO TAPE SUBSYSTEMS (VTS)

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c.   Tape Section - Contains video tape being recorded or revised for distribution to sites.

d.   Tape Electronics Section - Processes and distributes video from the data input section to the tape section and from the tape section to the buffer section.

e.   Buffer and Filing Electronics Sections - Provide temporary storage and transmission of images recorded on video tape of the tape sections to the console display section for checking and for quality control.

6.4.7.4   On-Site Equipment Functions

a.   Tape and Tape Electronics Sections - Video tape sections are employed for the recording, storage, searching, readout and replacement of video images and data retrieval codes on video tape. Each tape section contains one reel of magnetic tape that has a minimum storage capacity of 44,000 frames of data. The associated electronics section contains units for video routing, servo electronics, and sync-pulse generation to interface the various equipment sections with the system control section.

b.   System Control Section - A programmable data processor contains an 8000 word memory and stored control program to search the video tape sections and buffer for the address corresponding to the retrieval code set into the keyboard at any of the display sections, the filing section, or the printer. When a selection is made, logic circuitry determines if the image is in the central file or buffer. In the event a request is made to an in-use video tape section, the frame address is held until the section is accessible or the request is cancelled. A teletypewriter and punched paper tape reader is used as an input/ output communicator with the system control section. An activity log is automatically maintained to show the retrieval code of each frame requested, the location requesting data, the security classification of the data, and whether or not a hardcopy print was requested.

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c. Buffer and Buffer Electronics Section - One buffer section and buffer electronics section is used between each tape section and mobile data display section. Its primary purpose is to temporarily store the requested data frame(s) on magnetic discs, for display on the associated mobile data display section for as long as required, leaving the central tape file free to answer other requests. Each buffer section has a maximum capacity of 225 frames of data.

d. Filing Section - Used to load the buffer sections by assembling blocks of related maintenance data into buffer sections to support specific maintenance activities. A telety. ewriter is used for addressing the system control section and for printing activity log. Filing section also provides for making requests for hardcopy prints from the printer section and for viewing data on the console display section.

e. Filing and Printer Buffer and Buffer Electronics Section - Contain the electronics and temporary storage for data frames requested from the printer section. In this manner, the central file is free to answer other requests. The filing and printer and buffer electronics sections are also used to present video to the console display section at the filing section where checks are made on the data being printed.

f. Video and Control Transmitter Section - Contains video transmission line distribution, balancing and impedance matching circuitry between buffer section and video and control receiver station.

g. Mobile Data Display Section - May be plugged into a view receptacle located within the work area. The video display is presented on a 11 by 17 inch CRT. A keyboard is used for the selection and display of images stored in the central file or associated buffer and for operation of the printer. Lockout circuitry is employed to prevent viewing or printout of classified material by unauthorized users.

h. Video and Control Receiver Section - Distributes video from each buffer to the appropriate video receptacles in the various work areas.

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i.   Printer Section - Requests for 11 x 17 inch prints are initiated from the filing, display and printer sections. Approximately 10 seconds are required to make a copy.

6.4.7.5   Information Retrieval Process

To select a frame of MDS data, the user inserts information into the keyboard relative to the data requested. For example, a schematic diagram is selected by first depressing U, then the part number of the unit, SD, and the required frame number. The user has several options available to him. He may choose to display the data on the display section or request a hardcopy print. He may also want to hold the frame for recall. Operating the hold-for-recall pushbutton on the keyboard, inserts this retrieval word into a hold register, freeing the keyboard to retrieve other data. After viewing other frames of data, he may display the stored schematic by depressing a recall pushbutton. This action recalls the frame previously put in hold and displays it on the monitor.

6.4.7.6   Supporting Technical Manuals

Supporting technical manuals are bound publications prepared within the overall MDS concept for use in specialized applications such as _ersonnel training and command level information. They are prepared in a format similar to regular technical manuals and do not normally duplicate information in the MDS display subsystem. The following are typical titles:

- Overall Weapon System Description
- System Program Description

6.4.7.7   Comments on the MDS System

The MDS system, with its centralized computer controlled operation-maintenance information/data bank, has one prime and distinct advantage over existing microfilm storage/retrieval systems. That advantage is the ease and speed of updating the stored data. However, this advantage can be nullified by the GIGI (Garbage In-Garbage Out) principle! It was not possible to obtain any criteria on the planned content and structure of the operation-maintenance information

proposed for the MDS computer-CRT presentation system. Dr. John P. Foley, of the Air Force's Human Resources Laboratory, stated at the FAA's Aircraft Maintenance Symposium on 9 December 1969 that little or nothing could be expected from the computer presentation of maintenance data - "unless we greatly improve the content and structure of most current maintenance data. Computers are glamorous but not magic! A computer cannot display quality data unless we humans give it quality material to display" Reference 59). Thus, specifications that carefully control the format/structure and content of the operation-maintenance "computer input" information, based on proven human-engineering precepts, should be available and/or developed before selecting a costly presentation device.

There is a danger in selecting the device first and then constraining the operation-maintenance information to the limitations of the pre-selected presentation device. The use of keypunched 35mm microfilm aperture cards (as the data input device), which were used to convert the MDS data into video and control signals suitable for recording on magnetic tape for display on CRT, appear to be the heart of this system. This also involves other costly scanning and CRT verification equipment. It is felt that more research must be conducted relative to the structure and content of a large "total" operation-maintenance information system such as would be required for an ABM system. Possibly, a microfilm system should be the predecessor of a complex mechanized CRT system. It could also serve as a backup system.

Also, thorough maintenance and fault analyses must be initially conducted to determine the specific "fault-fix" maintenance job requirements. The aforementioned analyses and structure/content criteria should be prepared before the optimum presentation device is selected. It is not known if this was done in the SENTINEL Program.

6.4.7.8   Recent MDS System Changes

Word was received from official Army channels (after this document was in final type) that the proposed MDS system described in the above paragraphs is

being changed, in the new SAFEGUARD Program, to a simpler 16mm roll film cartridge approach employing various combinations and types of readers/reader-printers. However, the SENTINEL MDS descriptive writeup has been retained in this document since it is an excellent portrait of the automated operation-maintenance information presentation system (AOMIPS) of the future! This change to a microfilm system is of interest for the following reasons:

A.   In designing a fully automated operation-maintenance information presentation system for a large complex weapon system, one should consider a simple reliable mechanical backup operation-maintenance information system! Thus, it is predicted that backup microfilm information systems will be an adjunct to the computerized CRT-AOMIP systems that will be supporting the intricate weapon systems of the seventies. (See Section 7 for additional information on this subject).

B.   This SAFEGUARD ABM design change is of great significance, since the Army has now joined with the Navy F-1 fighter program in employing a microfilmed technical manual system early in the design definition phase of a large weapon system. Thus, the SAFEGUARD and F-14 microfilm programs should be carefully monitored, since they are the first large programs that are designing their operation-maintenance information requirements around a microfilm concept.

6.5   SUMMARY OF OTHER OPERATION-MAINTENANCE
              INFORMATION PRESENTATION STUDIES AND
              APPLICATIONS

This section was limited to a cursory survey of recent military maintenance information presentation systems and applications that mainly related to microfilm presentation approaches. Numerous other operation-maintenance information presentation studies have been conducted. Figure 6.5 provides quick reference summary charts covering over thirty presentation concepts that have been developed primarily for the military services.

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The potential payoffs that will result from the selective usage of various portions of these presentation concepts are great! Thus, the proposed Boeing Logistics Technology Development "multi-information presentation" document mentioned in paragraph 6.1 should prove useful in selecting the maintenance information presentation development concepts, criteria and data best suited to support the many and varied systems/equipment and operation-maintenance levels that currently exist. Too much time already has been lost trying to find the "best single cure-all" approach.

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PROGRAM	ACRONYM	TITLE	AGENCY (Company)	COMMENTS
Navy (Ships) SONAR (Possibility)	DATOM	Data Aids for Training Operations & Maintenance	Navy (General Electric)	Employs unique system functional block diagrams. Permits rapid following of circuit paths. (Red is main path; secondary paths are in other colors.)
Navy (Ships) Tracking-Display & Army TM-11 Series	PYRAGRAM	PYRAmid DiaGRAM	Army & Navy (Hughes Aircraft)	Theory/Text, Functional Diagrams & Troubleshooting/Test are in separate manuals. Functional data interrelated by trinomial numbering---theory/text volume and troubleshooting volume use same numbers for specific functions and sub-functions.
Commercial	PC	Profile Cards	(Philco)	For technician with limited training. Information is on plasticized cards colored for various categories of instructions (green-procedure with power off; red-equipment with power on, etc.)
Aircraft Maintenance	MEMRI	Maintenance Engineering Management & Repair Information	(Republic-Hiller)	Combines OPTICS (Optimum Procedure Task Instruction Compiler) and Micro-Vue system. Job cards for malfunction, location and repair are stored and displayed in MicroVue equipment.
Commercial & Military - Printed Circuitry Checkout	TRACE	Transistor Radio Automated Circuit Evaluation	(Philco)	Consists of test panels with supporting data for each circuit board. Panels fit over board or unit being tested. Servicing data is printed on each test panel-test point locations (holes), signal flows, and test values.

FIGURE 6.5   IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

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USE FOR TYPEWRITTEN MATERIAL ONLY

PROGRAM	ACRONYM	TITLE	AGENCY (Company)	COMMENTS
Navy (WEPS) Unidentified Surface Missile Ship Components	IMP	Integrated Maintenance Plan	Navy (WEPS) (Vitro Lab)	IMP is a system of preparing equipment manuals rather than a unique system of presenting maintenance data.
Commercial TV Set (test vehicle)	ATOMS	Automated Technical Order Maintenance Sequences	Boeing (D6-10566) (D6-6667)	Programmed troubleshooting (branching logic technique) similar to FORECAST. Step-by-step troubleshooting sequences developed for a commercial TV set.
Naval Air Technical Services Facility-Philadelphia (under development)	EDMICS	Engineering Data Management Info Control System	Naval Air Systems Command	Centralized storage bank of engineering drawings and data. A computerized retrieval system using microfilm aperature cards, AUTODIN networks for transmission, and microfilm receiving stations.
Experimental May be developed in conjunction with MIARS program.	TMMICS	Tech Manual Management Info Control System	Navy (Proposed collaborative system)	Combines MIARS and EDMICS. Categorizes tech manual info into 3 classes depending on usage. Data on microfilm is optically scanned, digitized and put on mag tape, etc.
Navy and Marine Aircraft & Weapons	DIP	Document Improvement Program	Naval Air Systems Command	Five year documentation improvement program aimed at better communications between designer and user, reducing bulk and providing easier storage and retrieval of timely data.

FIGURE 6.5 IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

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THE *BOEING* COMPANY

USE FOR TYPEWRI. _N MATERIAL ONLY

PROGRAM	ACRONYN	TITLE	AGENCY (Company)	COMMENTS
Navy Aircraft	MLARS	Maintenance Information Automated Retrieval System	Navy NASC and NATSF	Combines features of WSMAC, RAPIDS and NARF-JAX microfilmed technical manual systems
Army Aircraft (Rotary-Wing) Depot Maintenance	FLAT TOP	Technical Data Automatic Retrieval System	Army	Converted seaplane tender in Viet Nam with automated technical manual/engineering data presentation systems
F-4	WSMAC	Weapon System Maintenance Action Center	Navy (McDonnell-Douglas)	Organizational Level microfilm technical manual system with logic tree trouble-shooting. Still being tested.
Aircraft, Ships, Missiles and Commercial	SIMM	Symbolic Integrated Maintenance Manuals	All Services & DOD TMSS Project 0207	See Boeing Logistics Staff document D2-125568-1 for evaluation of SIMM concept. Also see MIL-M-24100A.
Navy Ships & Missiles	DD	Design Disclosure	Navy	Engineering design communication concept that results in SIMM manuals. See D2-125717-4 for evaluation.
C-5A	MADAR	Malfunction, Detection, Analysis and Recording	Air Force (Lockheed)	Troubleshooting diagnostic analysis system that monitors selected data points (950 test points) in automatic mode; manual or diagnostic mode employs 10,000 16 mm frames.
Safeguard	MDS [1]	Maintenance Data System	Army (Western Elec)	For operations and maintenance of Safeguard. Major subsystem is VTS (video tape). [1]

[1] MDS system recently changed to 16mm film cartridge system employing reader-printers.

FIGURE 6.5   IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

USE FOR TYPEWRI , MATERIAL ONLY

PROGRAM	ACRONYM	TITLE	AGENCY (Company)	COMMENTS
A-6A F-14A	RAPIDS	Rapid Automated Problem Identification Data System	Navy (Grumman)	Automated retrieval of troubleshooting and repair procedures keyed to actual aircraft malfunctions.
Nike-X	A-VIS	Audio-Visual Information System	Army (Bell Telephone Labs)	Tests indicate A-VIS is superior to tech manuals as a maintenance aid. Most effective mode tested was VIS (visual only)
Radar Set AN/SPS-46	FIST	Fault Isolation by Semi-automated Techniques	Navy (Ships), Dept. of Commerce, & National Bureau of Standards	Laboratory exercise only. Must be incorporated in original design. Retrofit not feasible. Radar set AN/SPS-46 was redesigned for FIST maintenance test.
None	ADMIRE	Automated Diagnostic Maintenance Information REtrieval	(Westinghouse)	Planning stage -- Requires built-in sensors, diagnostic computer and display system for data on 16 mm film.
Air Force Guidance System	VATE	Versatile Automatic Test Equipment	Air Force (Hughes Aircraft)	System for automatic fault detection and isolation to plug in module. Designed for depot maintenance.
Philco (Production Line Checkout)	ACE	Automatic Circuit Evaluation	(Philco)	Computer and test equipment tests Perma-Circuit boards to ensure that circuits are OK before installation.
NIKE-AJAX and test equipment (experimental)	MAIN-TRAIN	MAINtenance and TRAINing in Complex Equipment	Army (HumRRO)	Tested by Army Air Defense Human Research Unit (Fort Bliss). Tests proved that substantial increases in troubleshooting speed and effectiveness arepossible with improved tech manual procedures.

FIGURE 6.5   IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

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USE FOR TYPEWRIT MATERIAL ONLY

PROGRAM	ACRONYM	TITLE	AGENCY (Company)	COMMENTS
Navy LORAN Set (experimental) Army M-33 Fire Control	FORECAST	Derived from Task FORECAST	Navy & Army (HumRRO)	Preprogrammed troubleshooting. These decision type aids greatly reduced training time. Army M-33 tests indicated a 60% reduction in training time possible.
Martin-Marietta digital equipment	RESTORE	Rapid Evaluation System TO Repair Equipment	Martin-Marietta, Orlando Division	Manual prepared for each subsystem of complex digital equipment. Permits technician with little training to trouble-shoot. Size is 1/6th conventional manuals.
Hughes Aircraft Factory Test & Navy Mark 44/46 Torpedoes	VIDEO-SONIC		Navy (Hughes-Aircraft - Now produced by Weather-ford Corp.)	Audio-visual device with sequentially planned instructions on mag tape synchronized to 35mm slides. Has 6 x 8 inch screen. Navy is using for torpedo turnaround maintenance.
Air Force PIMO & Navy Air H-46 Helicopters	AUDISCAN		Audiscan Corp. / Serendipity (PIMO) & NAVAL AIR-Boeing (H-46)	Audio-visual device employing snap-in single cartridge (16mm film strip & synchronized audio-tape system). Used in PIMO and Navy H-46 Sigma II Sound/Slide Program.

FIGURE 5.5   IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

THE **BOEING** COMPANY

PROGRAM	ACRONYM	TITLE	AGENCY (Company)	COMMENTS
Army (MICOM) Sergeant Missile	MICROMS	Maintenance Information Concerning the Repair and Operations of Missile Systems	Army Missile Command (Pershing Project Mgr. Office)	A micro format tech manual concept using microfiche, unique Indexing technique, and a rugged portable reader-printer (dry process). Power pack and 16 mm roll film adapter are options.
Navy (Air) A-4, A-5 and A-7 aircraft)	JAXMS	NARF-Jacksonville Microfilm System	Naval Air Repair Facility - Jacksonville	Semi-automated microfilm technical manual system, based on airline experience. In operation for 2 years. Central management of changes. Uses 3-M reader-printer.
Army Aircraft Organizat. Level - 1st and 2nd Echelon (Under review)	None	Automated Microfilm "Job-oriented" Maintenance Information Presentation System	USAAVSCOM Fixed Wing & Cargo Heli-copter Branch	Job oriented concept (similar to RAPIDS) keyed to actual malfunctions. Data provided for specific tasks starts with fault isolation and covers all maintenance actions. Microfilmed data is coded and stored in reader-printers for rapid retrieval. Also, provides maintenance management information and reduces burden of maintenance reporting.
Army Document Storage System (Under development)	HOLDOR	HOlographic Laser DOcument Retrieval System	Army Missile Command (Carson Laboratories)	Current system uses KBr crystals for storage, and light from helium-neon laser for document read-in and retrieval. In new system, document transparency recorded directly holographically in crystal. Retrieved document recorded directly onto hard copy or transparency (visual readout via eye piece).

FIGURE 6.5   IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

USE FOR TYPEWRI   MATERIAL ONLY

PROGRAM	ACRONYM	TITLE	AGENCY (Company)	COMMENTS
Army Missile Command Redstone Arsenal, Alabama	EDS -0009 -0016	Engineering Data Systems -0009 and -0016	Army Missile Command	These 2 operational 16mm roll film systems provide methods of collecting, storing, retrieving, and distributing engineering data to the user in various forms and formats (Reference 64).
Trident Jet Transport Flight Control System (Smith)	SADIE	Smith's Aural Diagnostic Inspection Equipment	British European Airways (BEA) & RAF	Uses magnetic tape cartridge. Trouble-shooting (TS) on 1 track and TS sequence logic (digital form) on other. Tape also references printed manual for additional illustrated data. Permits lower skills to troubleshoot complex equipment (Reference 60).
U.S. Army SE Signal Corps School	JOBTRAIN		HumRRO U.S. Army	Requires analysis of the effects caused by failed parts. Uses branching network of effects with symptoms in "job aid" manual (Reference 61).

FIGURE 6.5   IMPROVED OPERATION & MAINTENANCE INFORMATION PRESENTATION SYSTEMS

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7.0   CONCLUSIONS

7.1   INTRODUCTION

All types of microforms suitable for reducing the bulk of the current printed technical manual systems have been investigated. Equipment suitable for the storage and dissemination of technical manual information at the point of use has been examined. Airline technical manual microfilm applications have been reviewed. The results of recent military operation-maintenance information storage and presentation studies and applications also have been reviewed and critiqued.

The study was limited primarily to microfilm systems/equipment employing mechanical retrieval systems. The goal was to find presentation system/equipment that would result in improving the existing printed technical manual system. The following basic printed technical manual system problems, recently enumerated by the DoD and the military (Reference 63), were constantly kept in the forefront in seeking a solution to the problem:

- "The technical manual system has continuously grown throughout the past years due to the increased complexity of our weapon systems. The libraries have become bulky, contain numerous volumes, and the use of cross references makes the data difficult to interpret and even more difficult to use.
- Shipment of basic technical manuals and all changes, which must be collated into the manual by the user, present a tremendous task when large quantities of manuals are received by the user activity." - DoD/Military Ad Hoc Group, May 1969

7.2   CONCLUSIONS

7.2.1   Conclusions Relative to Basic Objectives

Two basic technical manual microfilm storage and retrieval system objectives were established. The first objective was to achieve a large reduction in the amount of space required to store the technical manual

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collection. The maintenance information microfilming studies, tests and applications reviewed all achieved a 92 to 98 percent reduction in the amount of space needed for printed technical manual storage. The second objective was to establish a storage record of optimum size, shape, and storage density that could be handled rapidly and inexpensively by machines for retrieval and dissemination of the desired information. The study proved that microfilm systems represent the most reliable and cost-effective means currently available for this established purpose.

7.2.2 Basic Conclusions

Other conclusions reached are as follows:

a. The use of mechanical microfilm presentation devices result in a reduction in maintenance time (in most applications) and enhance the usability, integrity and timeliness of the technical manual maintenance information.

b. Satisfactory readers and reader-printers are available for line, shop and depot usage. The military services are establishing firm requirements (criteria) for microfiche and 16mm readers and reader-printers that will result in standardized militarized models.

c. Satisfactory portable microfiche readers and reader-printers suitable for rugged field usage will soon be available.

d. Satisfactory militarized automated retrieval systems, and automated integrated reader-printers are being tested and will be available soon for military usage.

e. The following improvements and benefits, apart from the bulk reduction advantage, result from employment of microfilm technical manual systems:

USE FOR TYPEWRITER MATERIAL ONLY

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1. Guarantees the completeness, uniformity and integrity of all technical manual data at all locations. This valuable file integrity consideration means material cannot be removed from a manual on microfilm.

2. Retrieval time for maintenance information on microfilm is less than for publications on papers.

3. Definitely reduce chance for error in making technical manual corrections as it reduces responsibility for revisions and completeness of data from the bases and line stations to one location - the main distributing base.

4. It frees technicians, inspectors, etc. from making hand notes on technical manual information and data or from making frequent trips to manual racks for additional information Microfilm reader-printers and the technical manual microfilm library can be moved on rolling stands to the vicinity of the maintenance activity.

5. Duplicate sets of the technical manual microfilm data can be produced rapidly. The ability to print-out detailed procedures and take them to the job can not be overemphasized.

6. Lapsed time from inception to use is greatly reduced.

7. Work forms, required inspection forms, etc. reduced to microfilm preclude the necessity of printing, distributing and warehousing these items.

Thus, the employment of the new display equipment and microformatted information systems will alleviate many of the current printed technical manual storage, file integrity, retrieval time, updating, and distribution problems. The first benefit alone is considered by many in the military and industry to be as important as the economics involved. (Paragraphs 3.4.4.2.1 and 5.6.4).

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f.   The microfilming of existing printed technical manuals is a step in the right direction but this is only a partial answer to the current maintenance information presentation problem.

g.   An overhaul of the existing technical manual system requirements is needed, including improved fault isolation, procedures, content, format and indexing concepts.

h.   This overhauling should be done during 1970 so that job-oriented "fault-fix" maintenance information presentation systems tailored to standardized and proven microfilm equipment will be available to support the complex systems of the 1970s.

i.   Microfilm operation-maintenance information system applications must be integrated early into the overall contractor/customer maintenance support concept/requirements for the particular system/equipment under development.   This is mandatory since microfilm presentation systems must be part of the overall maintenance concept.

7.2.3   Conclusions Relative to DoD/Military Objectives

The following criteria has been established by the DoD/Military Ad Hoc Committee for technical manual/information systems:

"A Technical Informational System, in order to be adequate, must have the following objectives:

a.   Capable of significantly reducing equipment downtime.

b.   Reduce amount of material required.

c.   Simplify instructions.

d.   Provide rapid access to data.

e.   Expedite distribution of data.

f.   Minimize technical and clerical support.

g.   Facilitate control and distribution of change information.

h. Minimize cost of distributing publications.

i. Usable under all environmental conditions.

- DoD/Military Ad Hoc Group (Reference 63)

This study concludes that recent technical manual microfilm systems/
equipment (MICROM, etc) tested by the military services meet all
of the above criteria except for items "c" and "i". The last item ("i")
soon will be met when the new militarized field-tested reader-printers
are available. Item "c", "simplify instructions", can be easily met if
the technical manual format/content flexibility potential of microfiche,
as explained in Appendix A, is exploited! Format flexibility is one
of the greatest advantages inherent in a microfilmed technical manual
system. This is especially true of systems employing task-oriented
procedures (such as the PIMO Program) which require considerable
more pages than conventional systems. The task-oriented procedures
require more illustrations and less text per page and, as a result,
more pages, but this is no problem in a microfilm system. The PIMO
"booklet" approach required over four times as many individual
technical manuals (in comparison to conventional MIL-M-25098 manuals).
Troubleshooting charts (used in PIMO) present no usage problem if they are
microfilmed. Appendix "A" describes the vast potential in arranging
horizontally and vertically various kinds of maintenance information on
microfiche. Anyone familiar with technical manual layout will be
intrigued, as was the U. S. Army, with the layout and other potential
inherent in microfiche. This study concludes that all of the nine
"Technical Information System" objectives cited above can be met with
microfilm equipment that will be available in 1970.

7.2.4   Human Factor Conclusions

One item not mentioned in the aforementioned DoD/Military criteria is
acceptance by the user. Many of the objections to microfilm approaches
in past years concerned user acceptance relative to the limitations of

human vision and the inadequacies of human memory and comprehension.

The vision limitations have been to a large extent, corrected by brighter, clearer, larger and shaded (non-reflective) viewing screens that have resulted from improved optical systems. The incorporation of newly developed zoom lens and the dual magnification option (a 2X or greater enlargement of the actual 8 1/2 x 11-inch page size shown on the screen). enables the technician to scrutinize any portion of a complex diagram or chart.

The second human factor - the inadequacies of human memory (short term) and comprehension, can be largely overcome by redesigning or "repackaging" the current printed technical manual/page content and format. Also, the new dual screen readers permit the comparison of the text on one frame (page) with an illustration or chart on another frame. Many of the problems associated with past microfilm presentation system applications were due to the employment of microfilmed technical manual pages in toto.

The human engineering elements, including "how" the maintenance information will be used, must be considered in every technical manual microfilm system! This study concludes that this problem is surmountable if the proper viewing equipment is selected and the content/format of the information is tailored to the equipment/user needs. The current printed maintenance information must be compressed and rearranged so that each page is self sufficient for the task being performed. Cross references to other frames (pages) must be curtailed and maximum use must be made of vast storage capability of microfilm.

7.2.5   Microfiche/Roll Film Conclusions

Finally, this study concludes that microfiche and microfiche jacket systems have the greatest immediate technical manual potential. It is recognized that the Navy MIARS program with WSMAC, RAPIDS,

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F-14 and the NARF/JAX systems use 16mm roll film. The PIMO
ar. 1 MDS (SAFEGUARD) systems also employ 16mm roll film. Most
of the major airlines also use roll film systems but in the past
year a trend towards microfiche (and jackets) has been developing
(paragraph 4.5).

Microfiche was selected as the best media for maintenance information
presentation systems due to its flexibility, and the fact that it is
rapidly becoming the national and international microfilm standard. Also,
simple, low-cost and easy-to-maintain microfiche (and jacket) readers (in-
cluding portables) are being employed in increasing numbers in
military, industrial and educational circles. Microfiche and microfiche
jacket systems also have a cost advantage over other microfilm systems,
according to U. S. Army studies (Reference 23). They cost less than
other microforms when used in information storage systems involving
a modular approach (technical manuals are modular in that they are
tailored to systems, equipment, tasks and other categories), with each
module containing less than 200 pages. Individual technical manuals,
on the average, contain less than 100 pages. The lower cost microfiche
factor is also applicable to systems that require frequent updating and not
a large number of dissemination points (also characteristic of technical
manual systems). The jacket approach permits low cost and rapid updating
of various frame sizes (16 or 35mm or other sizes as shown in Figure A-1).
This permits double size, fold-out, 10-foot wiring diagrams, "D" size
drawings, and even colored SIMM pages, to be included on a single
microfiche. No other microformat has the flexibility of microfiche
jackets! These are the main reasons, this study concludes, that
microfiche has the greatest future potential for technical manual applications.
For other microfiche/jacket advantages, refer to Appendix "B", Figure
4.6.2.1 and paragraphs 4.5.2, 4.5.3 and 4.6.

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APPENDIX A

A-0.   MICROFICHE TECHNICAL MANUAL FORMAT
             CONSIDERATIONS

A-1.   GENERAL MICROFICHE LAYOUT INFORMATION

Many of the current technical manual microfiche applications (including
all of the airline applications described in Section 5) have simply micro-
filmed the standard printed-technical manuals in the existing page number
sequence without making any format changes. The microfiche is read
in the reader from left to right and from the top to the bottom of the fiche
as in a conventional book. The standard National Microfilm Association
(NMA) microfiche used in the U. S. Army Microm program, and in other
military and commercial programs described in this document, has 98
available frames and the first top left frame (A-1) usually contains a table
of contents keyed to the frame numbers. One frame represents a standard
8 1/2 x 11-inch technical manual page. The physical size of the microfiche
and the size and location of each frame are fixed by NMA standard specifi-
cation M-1-1966. A fixed format is necessary for production and user
compatibility with existing commercial equipment. The microfiche readers
and filming equipment are calibrated for the correct placement of each
frame on the microfiche. Each of the 98 fixed frames has an identifier.
The first frame in the upper left is A1, the last frame in the lower right is
G14, etc. as shown in Figure A-1 (top illustration). However, this fixed
format does not limit the technical manual writer or editor from using
multiples of the microfiche frame units, as shown in the top illustration
on Figure A-1. A two page foldout would occupy two frames. A 20 x 30-
inch sheet would occupy 4 frames. A 10-foot schematic diagram would
occupy a complete row of 14 frames.

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HEADER INFORMATION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A		Standard 8 1/2 x 11-inch Pages												
B		Double Page Size												
C		Fold-Out Pages												
D		10-Foot Wiring Diagram Strip												
E		"D" Size Drawing												
F		(on 35 MM)												
G		Computer/CRT Generated												

105.0 —
87.5 —
75.0 —
62.5 —
50.0 —
37.5 —
25.5 —
12.5 —
0.0 —
-4.0 —

REFERENCE CORNER

-4.0 — 0.0 — 10.0 — 20.0 — 30.0 — 40.0 — 50.0 — 60.0 — 70.0 — 80.0 — 90.0 — 100.0 — 110.0 — 120.0 — 130.0 — 140.0 —

MICROFICHE DIMENSIONS/LAYOUTS

USE FOR DRAWING AND HANDPRINTING — NO TYPEWRITTEN MATERIAL

1 2 3

D

STEP-BY-STEP PROCEDURES

SUPPLEMENTAL DATA

VERTICAL LAYOUT

FIGURE A-1   MICROFICHE LAYOUTS

A-2.   MICROFICHE HEADER

The top row of the microfiche is called the header. It's reserved for
the title, number, security classification, and other information necessary
for positive identification of the microfiche. The number assigned to the
microfiche should be placed in the upper right corner of the header, the
technical manual or document number is placed on the upper left corner
of the header as shown below:

Microfiche Header

The marking for the highest security classification is placed in the top
center of the header. Each frame containing classified information has
its highest security classification stamped on the material before it is
filmed, so these markings would be in micro-size. The Espionage Law
statement,and downgrading information,should be placed in frame A1,
preceding the index. Classified fiche should have a silk-screened blue
border 4mm wide.

For multi-sheet microfiche, the headers are identical except for sheet
numbers. However, each sheet begins with frame A1 because viewing
equipment is labeled A through G. Cross-referencing within a multi-
sheet microfiche is by microfilm number (MF), sheet, and frame
identifier. For example, the first frame in sheet 2 of microfiche 8 is
frame 8-2A1.

A-3.   VERTICAL MICROFICHE LAYOUTS

Vertical layouts are shown in the bottom illustration on Figure A-1. The
Army (MICROM Program) found that a vertical format was suitable for
Field Level type manuals used for checkout of missile components in the
electronic repair vans. These manuals averaged around 75 pages. Most
of the technical data in these manuals supplemented the manual procedures
the technicians followed in the initial checkout and troubleshooting of the
chassis.

The layout and indexing concept, the Army employed for these van
"microfiche manuals" was systematic and can be applied to other technical
manual microfiche programs. First, the Army placed the step-by-step
procedures in one vertical column, as shown in Figure A-1. Then, they
arranged the supplemental procedures and data in the row at which they
supplement a particular step of the procedures. For example, if a 100-
step procedure filled the 7 frames of column 3, the procedures would be
sequential from top to bottom. If the technician ran into a faulty indication
in step 50, row D would contain the troubleshooting procedures, schematic
diagram of the circuit being tested, applicable theory, exploded view
illustration, repair instructions, and repair parts information. If pre-
test instructions and diagrams were needed for any of these steps, they
would be placed in column 1 and 2.

If the supplemental data exceeded 11 frames for a particular step of the
procedure, the Army had two options. They could place the 12th frame
of data in any unused frame on the microfiche and reference it, or use
a horizontal format, as described below. Note that not every frame is
filled when using a vertical layout. Also, not every group of steps will
have 11 frames of supplemental data.

A-4. HORIZONTAL MICROFICHE LAYOUTS

If the procedures averaged 10 to 12 pages and the supplemental data exceeded 11 pages, the Army used a horizontal layout in which the procedures were arranged sequentially from left to right, as shown in Figure A-4. The supplemental data was arranged in two groups, one group above and the other below the procedures, or all supplemental data was arranged in one group below the procedures.

A-5. OVERSIZED SCHEMATIC MICROFICHE LAYOUTS

Extra-long and extra-wide illustrations, which are usually schematic diagrams, present unique problems in layout. The first goal is to use the original schematic without redrawing it. If the schematic is 12 x 100-inches, it would be filmed with a flow camera as a whole and stripped into the appropriate row of the fiche, as shown in Figure A-4. The procedures would be placed above and below row D. Usually the procedures are written around specific input and output points on the schematics and are so placed on the microfiche. If the technician encounters an abnormal indication, most of the data he needs is in one column.

Extra-wide illustrations are handled in the same way. The extra-wide diagrams are photographed with a 35mm camera and stripped into the appropriate frames on the microfiche, as shown in Figure A-1.1.

A-6. OTHER MICROFICHE FORMAT CONSIDERATIONS

A-6.1 Microfiche Layout Planning Sheet

Figure A-6.1 shows a typical microfiche layout sheet that could be used by the technical writer or editor in planning his microfiche layout. The use of vertical, horizontal, and other layouts previously described would be determined by publications planners in the early phases of the program, using similar layout sheets. The final use of these layout sheets would be by illustration layout personnel who would use the final text and illustrations to "dummy" the technical manual fiche(s). These layout sheets would also

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SUPPLEMENTAL DATA

STEP-BY-STEP PROCEDURES

SUPPLEMENTAL DATA
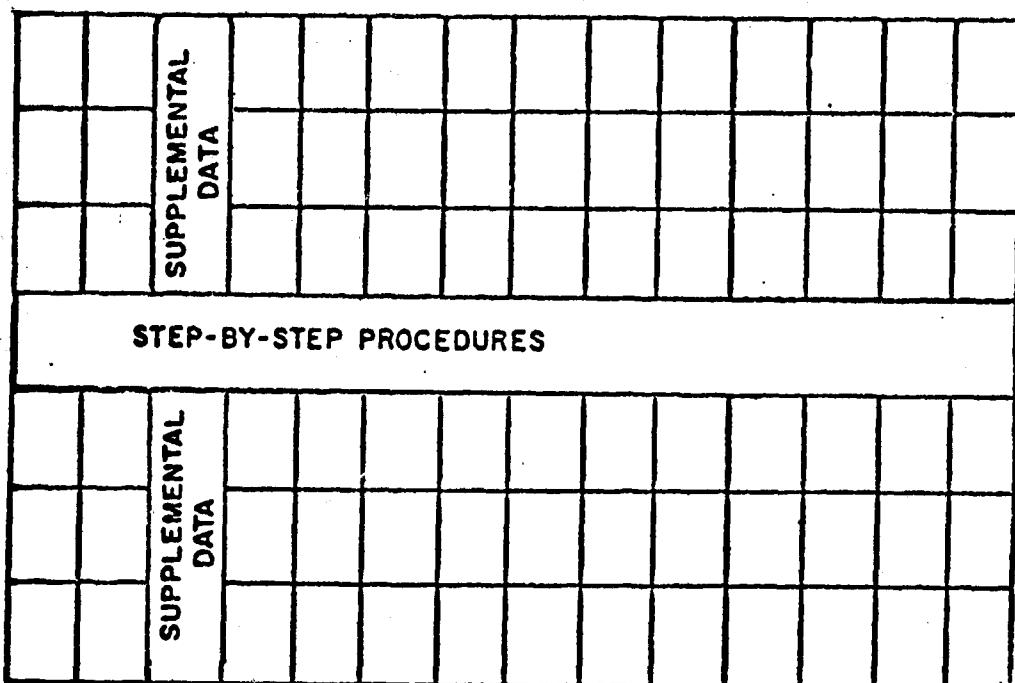
HORIZONTAL MICROFICE LAYOUT

PROCEDURES

PROCEDURES

PROCEDURES

D   EXTRA-LONG SCHEMATIC →

PROCEDURES

PROCEDURES
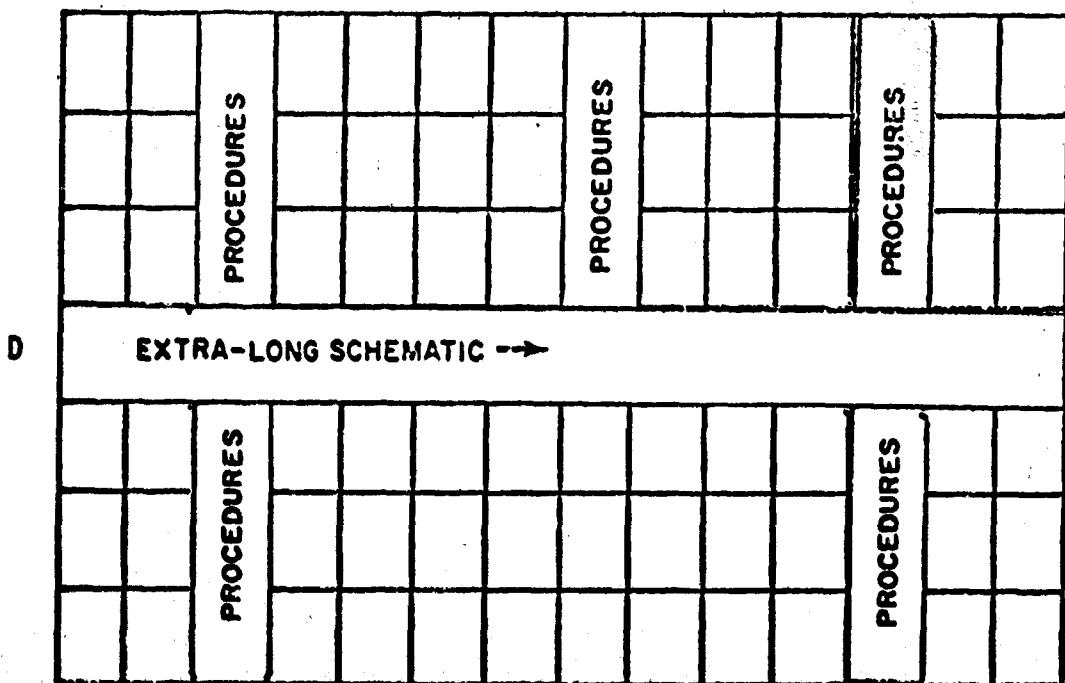
LARGE SCHEMATIC DIAGRAM LAYOUT

FIGURE A-4 TYPICAL MICROFICHE   LAYOUTS

T.M._____ T.M. DATE_____ APPR'D BY_____ DATE_____

TITLE___ MF #___

NOTES:

FIGURE A-6.1 MICROFICHE LAYOUT SHEET

be used by the microfiche camera operators who must know the sequence
in which to film the pages, and by the strip-in operator who puts together
the final master fiche(s).

The 16mm camera operator films one row of frames (pages) at a time,
normally from left to right, with blank frames internally as required by
the layout sheet, and with a few blank frames at the ends of rows to allow
for binding the edges of the master fiche. The 35mm camera operator films
two rows of frames at a time. One exposure on the planetary camera contains
eight frames of the microfiche. For example, the camera operator places
frames (pages) Al through A4 and B1 through B4 on the copyboard for the
first exposure. Eight standard technical manual pages can be photographed as
a whole.

A-6.2   Microfiche Frame (Page) Numbering

In a large technical manual program, cameras that automatically identify
each frame (page) should be used. This page identification should employ
a large white-on-black number similar to the page identifier shown on the
bottom of this page. If an automatic page identifier microfilm camera is
not used, then adhesive-backed sheets of frame (page) identifiers (white-on-
black) should be made by the illustration group. The illustration group
would paste these large size alpha-numeric frame (page) numbers on the
paste-up pages, in accordance with the microfiche layout sheet instructions.
These large size frame (page) identifiers are necessary for filming and
maintaining file copies of the original material. They also must be used by the
operator in locating a particular image to be viewed on the screen. The frame
identifier appears in the bottom center of the reader screen. It would be
obvious to the user as to which direction to dial if he were viewing frame A1,
and the text referenced him to frame A12.

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A-6.3   Microfiche Cross-Referencing

Cross-referencing within a given microfiche, should be by frame identifier rather than page number, i.e., A2. Figure and paragraph numbers should precede the frame number, i.e., Figure 2, A2 or Paragraph 7.2, B3. The microfiche number should be used when referencing to another microfiche in the technical manual microfiche series, i.e. MF8. Normally, the frame identifier is not included in the reference. If the identifier must be used, place it following the microfiche number with no space separation, i.e., MF8C3. The index prepared for frame A1 of each microfiche should list the appropriate paragraph, table, figure, and frame identifier.

References to other technical manuals or even to other microfiche manuals can be held to a minimum because of the low cost of placing technical manual information on microfiche. The referenced material should be duplicated and placed in the microfiche at the point of the reference. For example, rather than refer to a 75-page manual covering a small test set for 3 pages of operating instructions (needed for the microfiche procedure), the 3 pages should be duplicated in the appropriate frames. Before filming, a mast should be placed around the referenced material, similar to the one shown below. These masks can be made up in standard sizes. The border will appear on the viewer screen, so that the user will know that these pages were duplicated from some other manual.

REFERENCED
MATERIAL

US 4807 1414 REV. 8-85
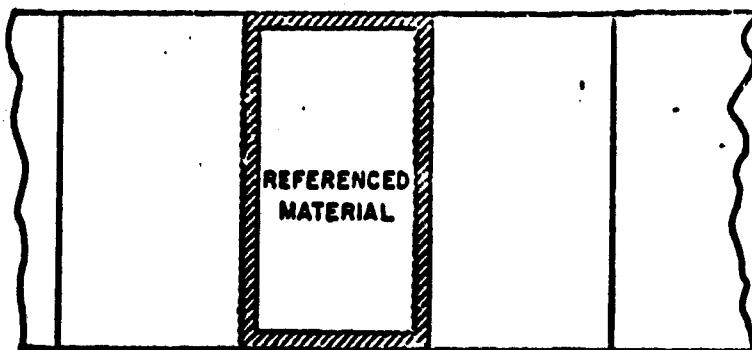
A-6.4   Microfiche "Reference" Technical Manual

The volume of referenced material should determine the most appropriate
method of layout. If large quantities of reference information (text and
illustrations) are required for a given program, all the reference material
(from numerous manual sources) could be placed on separate microfiche(s)
with a special color coded header(s) and provided an MF (system) number.
Then, all other microfiche would reference it by number. In this case, the
mask would not be needed. However, in general, the reference material
should be integrated into the microfiche to avoid excessive referencing.

A-6.5   Microfiche Last Frame Information

The following information is usually provided on the last recorded frame
(page) of each microfiche.

- End or continued, whichever applies
- Date filmed
- NBS 1010 Microcopy Resolution Test Chart

A-7   TECHNICAL MANUAL/INDIVIDUAL
                             MICROFICHE CODING

The problem of identifying the correct microform(s) for a given maintenance
task at the point of use was discussed in Section 3 where the advantages of
16/35mm closed loop and cartridge systems were emphasized. In the 16mm
systems, up to 2,600 pages are stored in a single container and individual
frames can be retrieved automatically for viewing in a reader. In a
microfiche system, only 98 frames (at the most) can be placed on an
individual fiche. Thus, each individual microfiche must be numerically
(on microfiche header - paragraph A-2), color and/or physically coded for
quick and accurate retrieval as follows:

<u>Numerical (Header) Coding</u> - The top row of the microfiche called the header contains the technical manual number, title and classification that is eye-legible when the microfiche is stored in a tray, and magnetic file or "Acme Visible" rack. The Acme files that are used by the airlines (paragraph 5.6.3) hold approximately 30 microfiche per side in single frames or 60 microfiche per side in double frames in ladder-type pockets which leaves only the heading visible. Thus, the maintenance technician usually can quickly read all headings without handling the microfiche.

<u>Color Coding</u> - Color can be used in addition to the header coding when the eye-legible technical manual number and title are inadequate for quick retrieval. Color can be inexpensively used for coding microfiche by the following two methods. First, there are several types of film bases which require no special developing techniques or equipment to produce tinted microfiche. There are more than 10 different colors available. For example, classified material may be placed on colored microfiche. The image would appear in color in the viewing equipment. The second method is silk-screening. Black or color stripes may be placed at any desired standard location on the fiche. A pre-cut silk screen, the size of a standard microfiche, can be used for this coding. A paint, of the color desired for the code, can be brushed or sprayed onto the silk screen.

<u>Mechanical Coding -</u> A standard size microfiche has a 4mm border. Holes of varying shapes may be punched in these borders easily with inexpensive equipment. Notches may also be used for "finger" or "eyeball" searching for specific microfiche. Paragraph 4.2.3 describes the "Selectriever" automatic mechanical retrieval system (35 round holes along bottom edge of film card).

The above coding methods may be combined to identify unique microfiche maintenance information systems tailored to specific system/equipment configurations and types.

APPENDIX B

MICROFICHE CHARACTERISTICS CHECKLIST-
TECHNICAL MANUAL PROGRAMS

Volume and weight reduction	Approximately 97 percent. 10,000 letter-size pages weighing 47 pounds reduce to 100 fiche weighing less than 1 pound.
Retrievability	Excellent due to effective indexing and convenient accessibility.
Cost to produce	Approximately 14 cents per fiche copy in volume production, $6.41 each for masters.
Ease of correction and updating	Excellent. Only a portion of one fiche will normally need to be rephotographed as compared to rephotographing up to 2600 pages of roll film to make a correction. Low cost permits economical production of complete documentation units specifically tailored to each unique equipment configuration.
Flexibility of format	Superior. Related material can be arranged in adjacent frames for convenience in troubleshooting and repair. Reference data can be included to eliminate cross referencing. Extra long and extra wide illustrations (usually schematics) can be filmed as a whole and stripped into appropriate area on fiche.
Speed of production	Superior. Assuming camera ready copy, fiche masters and copies can be made in 24 hours or less (duplicates one a minute).
Speed of distribution	Superior. Fiche copies can be air mailed at same or less cost than books can be mailed 4th class. Fiche cost and convenience of mailing has advantage over roll film, which requires packaging.
Usage	For maximum effectiveness, viewers designed for fiche are required. However, fiche can be read with hand magnifying glass, hand viewer, or aperture card viewer.
Hardcopy compatibility	Highly legible full size copy can be produced at cost ranging from 3 cents to 8 cents per page of copy.

Source: U. S. Army MICROM Program

US 4402 1434 ORIG. 8-69

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APPENDIX C

VENDOR CONTACTS

Technical information from the following companies was reviewed for this study. This information is filed in the ASG Logistics Engineering Information Center (2-5042).

Admaster
Audiscan
AMF
Atlantic Microfilm
Bell & Howell, Micro-Data Division
Benson-Lehner
Berkey Technical
Brown Engineering (Teledyne)
Bunker-Ramo
Burroughs
Conductron - Missouri
Decision Systems
Dennison Readex
Dorsett Educational Systems
Dukane
Eastman Kodak
Educational Computer
Eugene Dietzgen
FMA
General Dynamics
General Electric - Electronic Systems Division
General Precision - Link Group
Grumman
Hughes Aircraft
IBM
Image Systems (Houston Fearless)
Information Handling Services
ITEK
Kalart

Klitten
Ken Cook
Litton Industries - AMECON Division
Lockheed
Magnavox
Martin-Marietta
Mast Development
Merganthaler Linotype
McDonnell-Douglas
Microform Data Systems
Microformation Systems (Micromation Technology)
Mosler Information Systems
3-M
National Cash Register
Norelco
Peripheral Technology
Photomechanisms
RCA - Graphics Systems Division
Readex Microprint (Dennison)
Remington Rand (Sperry Rand)
Sanders Associates/Diebold
Stromberg Datagraphics (General Dynamics)
Taylor-Merchant
Washington Scientific Industries
Western Reserve Electronics
Western Electric
Westinghouse - Surface Division (Sperry Rand)
Univac (Federal Systems Division)

U3 4807 1414 PFV. 8-68

APPENDIX D

SOURCES OF BACKGROUND INFORMATION

Organizations and individuals active or interested in microformatted technical manual approaches and in improving job performance aids and maintenance information presentation systems include the following. An asterisk after a name indicates that this individual was contacted during this study.

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       Joseph A. Anderson *

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APPENDIX E

BOEING TECHNICAL MANUAL MICROFILM PROGRAM

The Boeing Commercial Airplane Group in 1968 converted its huge library of printed manuals of over 18,000 volumes to a 16mm microfilm system. The following statistics and illustrations clearly indicate that the printed manuals Boeing used in 1968 presented a difficult storage and distribution problem. These statistics are for the 707, 720, 727 and 737 aircraft. The 747 aircraft technical manual microfilm program was implemented in the second half of 1969.

APPROXIMATE MANUAL DISTRIBUTION
  WITHIN BOEING
  · 6 Complete Libraries
  · Field Service Reps
  · Projects, etc.

3400 Volumes - Illustrated Parts Manuals
9400   "   - Wiring Diagrams Manuals
5525   "   - Maintenance Manuals
375   "   - Overhaul Manuals
135   "   - Structural Repair Manuals
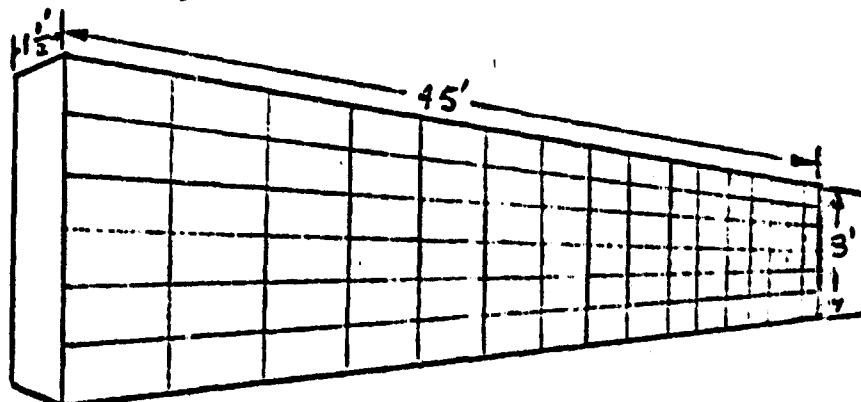
Reader-
Printer

A complete printed manual library
is a row of shelving 45 feet long
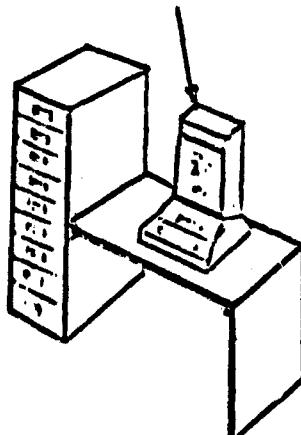
A complete micro-
film library is
contained in a 5
foot file cabinet
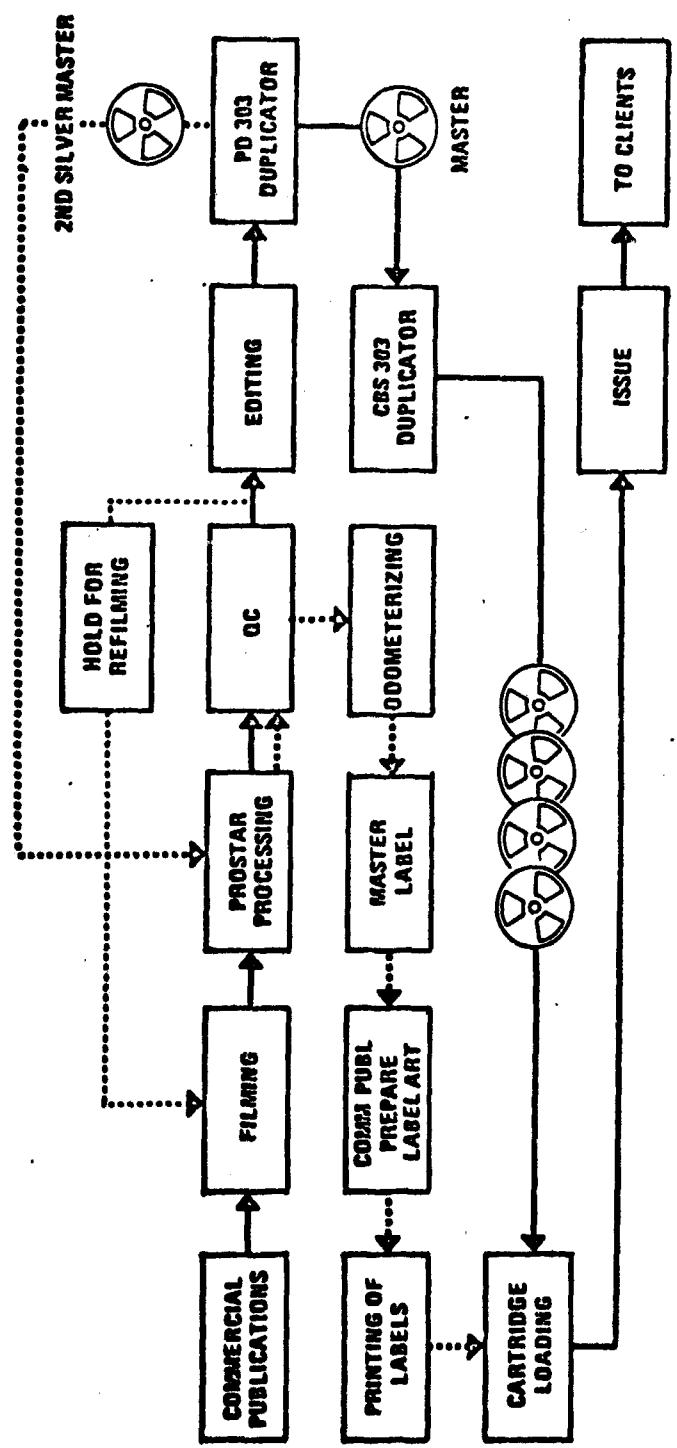
FIGURE E-1 .   BOEING TECHNICAL MANUAL MICROFILM PROCESS

Figure E-1 shows the microfilm process employed. The Publications Group produces and maintains a master paste-up copy of each manual. They furnish a camera-ready master, complete and in correct sequence to the Administrative Services Microfilm. Group in accordance with established filming schedules. A master copy of the cartridge label and the cartridge indexes, less odometer readings, are also furnished. The Microfilm Group produces the microfilm and distributes the cartridged film in accordance with schedules and listings provided by the Publications Group. The Microfilm Group determines the proper odometer readings for each roll, adds such readings to the index label, reproduces the labels and affixes the labels to the loaded cartridges. The camera film and/or working masters (second generation film) are maintained until replaced by subsequent revision film so that additional duplicate copies can be produced as needed.

The Publications Group is responsible for content, sequence and legibility of the master copy furnished. The Microfilm Group is responsible for the quality and legibility of the microfilm. The 16mm camera film (20:1 reduction ratio) must have a resolution of not less than 110 lines per millimeter.

Manuals are refilmed and distributed every three months to ensure that all users have the most current data available. Interim cycle revisions are distributed on paper as they occur. The microfilm system improved communication between Boeing's internal and field locations.

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USE FOR TYPEWR.   MATERIAL ONLY

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